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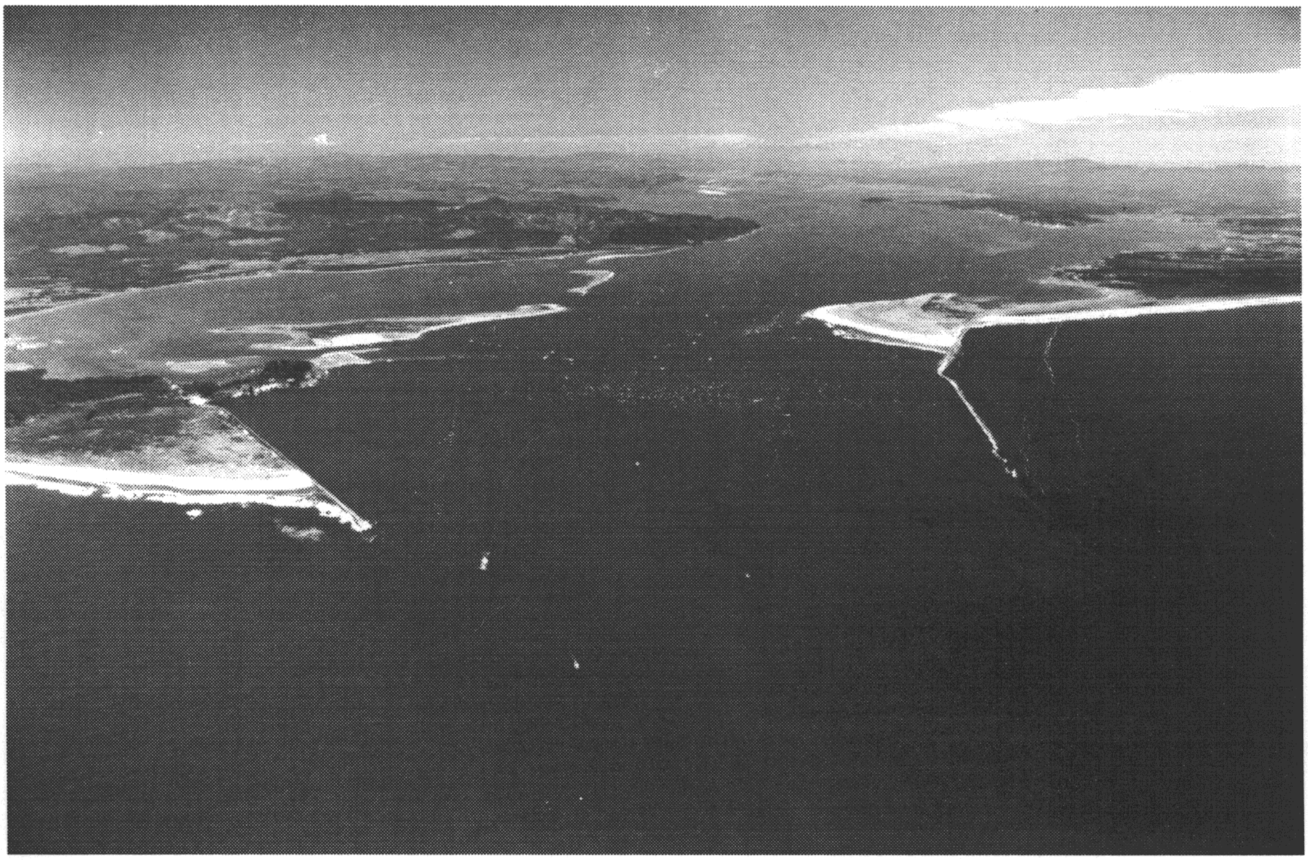
Reconnaissance Level Benthic Infaunal, Sediment, and Fish Study

Offshore From The Columbia River, July 1992



Final Report

RECONNAISSANCE LEVEL BENTHIC INFAUNAL, SEDIMENT, AND FISH STUDY OFFSHORE FROM THE COLUMBIA RIVER, JULY 1992

By

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INTRODUCTION

One of the major responsibilities of the U.S. Army Corps of Engineers (USACE), Portland District, is to maintain navigation channels in the Columbia River and its estuary. This requires annual dredging and disposal of millions of cubic yards of bottom sediments. Four Ocean Dredged-Material Disposal Sites (ODMDSs) off the mouth of the Columbia River have been designated by the Environmental Protection Agency (EPA) to receive dredged material. These sites are identified as ODMDSs A, B, E, and F and are used for disposal of materials dredged primarily from shoals at the entrance to the Columbia River, but may receive dredged material from other areas in the lower estuary. Average annual dredged quantities range from 4 to 6 million cubic yards, with most of the material disposed of at Sites A and B. Site E is used as a backup disposal area during unfavorable weather and sea conditions. Site F has been used little, except for disposal of material dredged during the 1989 Tongue Point Navigation Improvement project (Siipola et al. 1993).

Concern has arisen regarding the capacity of the existing ODMDSs offshore from the Columbia River, particularly Sites A and B. Mounding has occurred at these sites during recent disposal of dredged material. Temporary (5-year) spatial expansions of Sites A, B, and F were initiated by the USACE, Portland District, in 1992 while searching for a long-term solution for dredged material disposal.

To minimize negative biological effects, new ODMDSs should be located in areas with relatively low standing crops of benthic and epibenthic invertebrates and fishes. Also, candidate ODMDSs must be carefully evaluated from the standpoint of technical feasibility and economics. In July 1992, the USACE and the National Marine Fisheries Service (NMFS) conducted a widespread reconnaissance study of the benthic invertebrate community and sediment characteristics offshore from the Columbia River. The last widespread studies offshore from the Columbia River were conducted during the mid 1970s under the USACE's Dredged Materials Research Program (DMRP) (Richardson et al. 1977). A recent site-specific survey was conducted by the USACE, Portland District, at ODMDS F from 1989 to 1992 (Siipola et al. 1993). The primary goal of the present study was to identify benthic invertebrate and sediment characteristics over a large area offshore from the Columbia River. Samples were also collected at benthic stations established during the DMRP in 1974-1975 and data compared between the two studies. The present study included a limited survey of fishes and large epibenthic invertebrates in a nearshore area north of the mouth of the Columbia River.

METHODS

Sampling

Benthic Invertebrates

Benthic invertebrate and sediment samples were collected at 51 stations in an area offshore from the Columbia River, extending approximately 16 km north, 17 km south, and 16 km west of the river mouth (Fig. 1). Station depths ranged from 10.7 to 82.0 m. The Global Positioning System (GPS) was used to locate stations previously established by the USACE (Appendix Table 1). A 0.1-m^2 modified Gray-O'Hara box corer (Pequegnat et al. 1981) was used to collect bottom samples (Appendix Fig. 1). One benthic invertebrate sample was taken at each station, except at Stations 5, 9, 26, 31, 32, 36, and 37, where five benthic invertebrate samples were taken. Benthic invertebrate samples were preserved in 18.9-liter buckets with a buffered 4% formaldehyde solution containing rose bengal (a protein stain). Later the samples were individually sieved through a 0.5-mm mesh screen, and the residue, containing the macroinvertebrates, preserved with a 70% ethanol solution. Benthic organisms were sorted from the preserved samples,

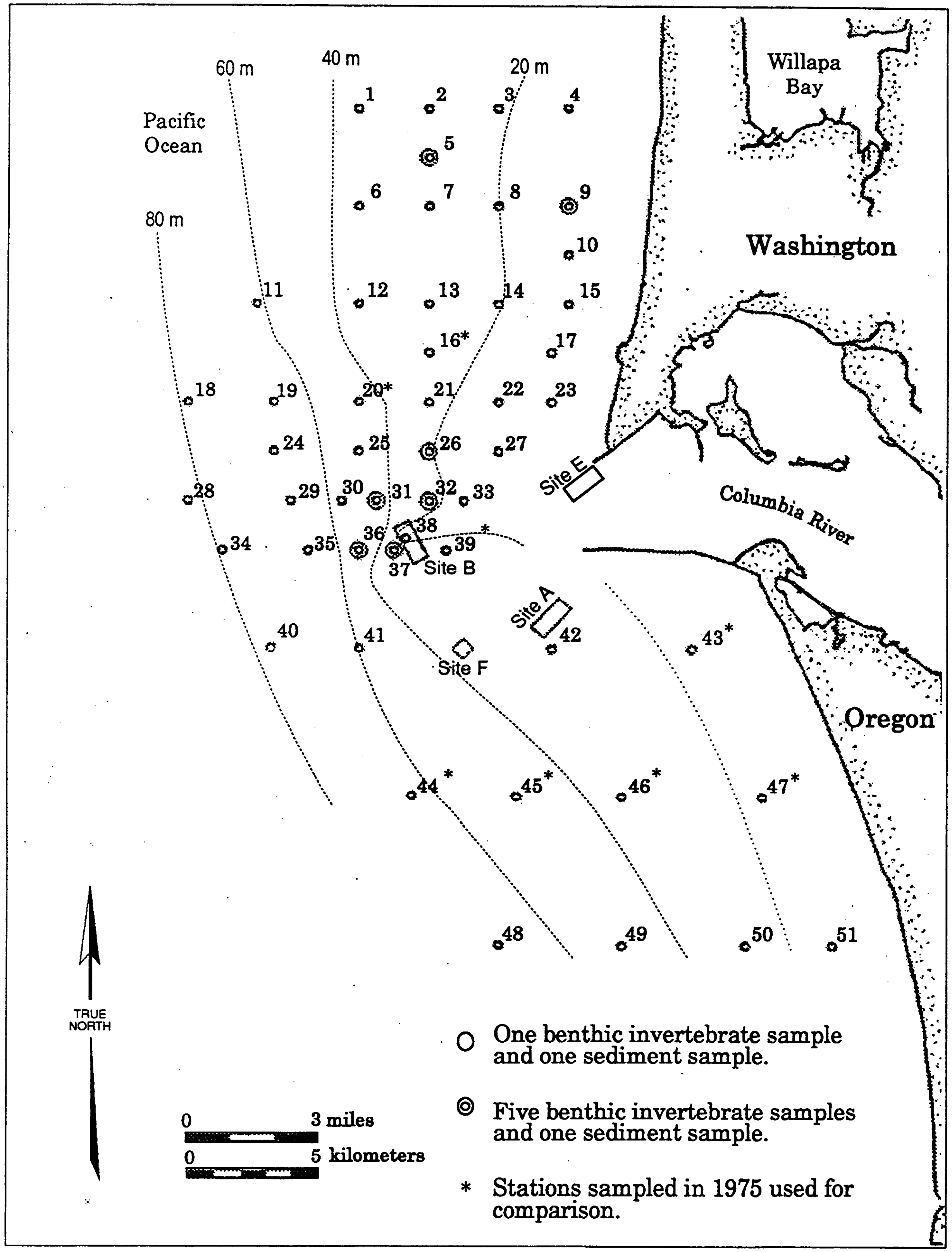

Figure 1.--Location of benthic invertebrate and sediment stations offshore from the Columbia River sampled during July 1992, with eight stations sampled in 1975 which were used for comparisons. Sites A, B, E, and F are ocean dredged-material disposal sites.

identified to the lowest practical taxonomic level (usually species), and counted. All specimens were placed in vials containing 70% ethanol and stored at the NMFS Point Adams Biological Field Station, Hammond, Oregon.

Sediments

Sediment samples for physical and chemical evaluations were collected at the 51 stations occupied for the benthic invertebrate sampling. The samples were collected from the box corer using an acid-rinsed stainless steel spoon, being careful not to collect material in contact with the box-corer sides. Samples for physical analysis were placed in labeled plastic bags and refrigerated until delivery to the USACE, North Pacific Division Materials Testing Laboratory at Troutdale, Oregon. Samples for chemical analyses were placed in two 250-mL commercially prepared sampling jars equipped with Teflon lids. The jars were placed in plastic bags and packed in iced coolers. The coolers were delivered to the testing laboratory for further processing and shipment to a contract laboratory. Five additional replicate samples were collected and forwarded to the contract laboratory as unidentified duplicates for quality assurance/quality control evaluation. These samples were labeled A through E and corresponded to the following stations: 9 (B), 31 (C), 32 (D), 36 (A), and 37 (E). During repetitive sampling at Station 39, two distinct sediment types were noted in the field. A representative sample of each was collected for analysis and labeled 39 and 39A.

Fishes and Large Epibenthic Invertebrates

Four bottom-trawling efforts were made during the July 1992 survey at the 9.4, 12.8, 15.5, and 18.6-m depth contours in an area just north of the North Jetty and adjacent to Peacock Spit (Fig. 2). All trawling efforts were 5 minutes long and were made

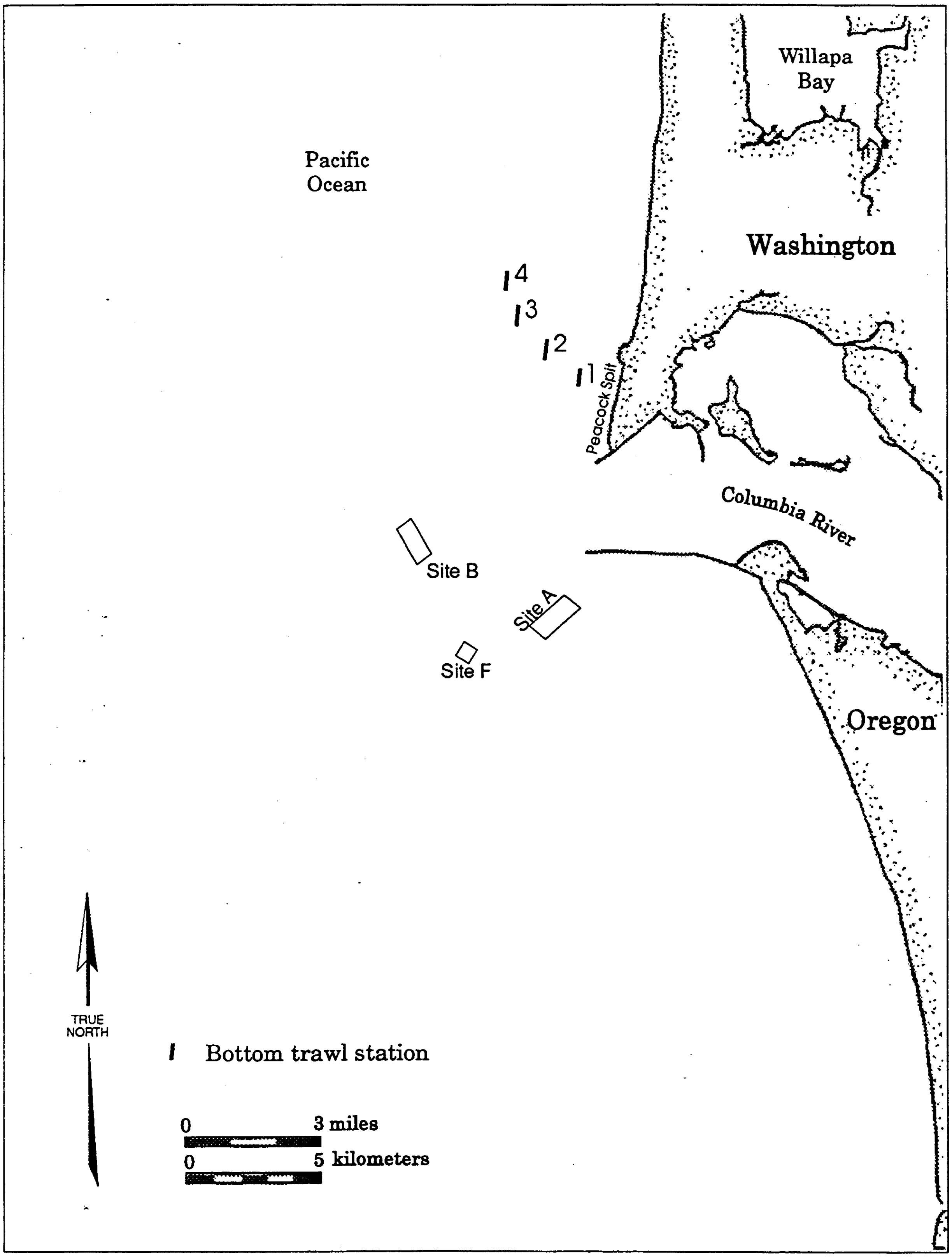

Figure 2.--Location of the 8-m bottom trawl stations offshore from the Columbia River, July 1992. Sites A, B, and F are ocean dredged-material disposal sites.

against the current. Bottom trawling was done with an 8-m semiballoon shrimp trawl that had an overall mesh size of 38 mm (stretched). A 10-mm mesh liner was inserted in the cod end of the trawl to ensure retention of small fishes and large epibenthic invertebrates. Location and distance traveled for each trawling effort were determined using the GPS (Appendix Table 1).

All organisms captured by trawling were weighed (g) and measured (mm). Measurements were; the total length for fishes, carapace width for Dungeness crabs (*Cancer magister*) and the rostrum to the distal end of the telson for shrimp.

Benthic Invertebrate Sampling--1975

In 1975, five replicate benthic invertebrate samples were collected at each station using a 0.1-m^2 Smith-McIntyre grab sampler (Carey et al. 1972). Contents of the grabs were washed through a 1.0-mm mesh screen. The material retained on the screen was saved in a container and fixed with a buffered formaldehyde solution for sorting at a later time. Station locations were determined using one or more of the following methods: Del Norte system, Loran-A, or radar fixes. Stations selected for comparisons to 1992 are indicated in Appendix Table 2.

Data Analyses

Benthic Invertebrates

For each station where one benthic invertebrate sample was collected, the total number of organisms was determined and the number of organisms/m^2 was calculated. For each station where five benthic invertebrate samples were collected, each sample was treated as a replicate, allowing calculation of a mean number of organisms/m^2 and standard deviation for each species and for each station. Two community structure indices were also calculated for each station. The first was diversity (H), which was determined using the Shannon-Wiener function (Krebs 1978):

$$H = -\sum_{i=1}^{s} p_i \log_2 p_i$$

where $p_i = n_i / N$ (n_i is the number of individuals of the ith taxon in the sample, and N is the total number of individuals in the sample) and s = number of taxa. The second community structure index was equitability (E), which measures proportional abundances among the various taxa in a sample (Krebs 1978):

$$E = H/\log_2 s$$

where H = Shannon-Wiener function and s = number of taxa. E has a possible range of 0.00 to 1.00, with 1.00 indicating that all taxa in the sample are numerically equal.

Cluster analysis, using the Bray-Curtis dissimilarity index with a group averaging fusion strategy (Clifford and Stephenson 1975), was used to identify station groupings that had similar species and densities for the July 1992 survey. A 0.5 dissimilarity value was considered a significant difference between groups. The number/m^2 or the mean number/m^2 for each species per station was used in the analysis. Species which had densities less than 10/m^2 were excluded from the analysis to reduce the effect of rare species.

Sediments

Physical analyses of sediments included grain size and volatile solids. Median and mean grain size and percent sand, silt, and clay were calculated for each sample.

Chemical analyses at each station included tests for percent total organic carbon (TOC); the heavy metals; arsenic, silver, cadmium, chromium, copper, mercury, lead, nickel, and zinc; pesticides; polychlorinated biphenyls (PCBs); and polyaromatic hydrocarbons (PAHs). Eleven analyses were conducted for polychlorinated dioxins (PCDD) and polychlorinated furan (PCDF) (Stations 5 through 8, 10, 23, 26, 28, 37, 42, and 45). Analytical methods and method detection limits are indicated in Appendix Table 3.

Fishes and Large Epibenthic Invertebrates

A descriptive summary of each trawling effort was produced by using distance fished, estimated fishing width of the trawl (5 m), and catch data. This summary included a species list, numbers and weights of fishes and large epibenthic invertebrates captured (by species and total), number/hectare (ha) (by species and total), weight/ha (by species and total), and the previously described community structure indices.

Benthic Invertebrate Comparisons between 1975 and 1992

We were unable to obtain a 1975 data set that corresponded exactly with the 1992 collections. The 1975 data set contained information from only eight stations, sampled in April, June, and September, that were from the geographical locations sampled in July 1992 (Fig. 1). Data from these stations were used for general comparisons with the 1992 survey.

From the limited 1975 benthic invertebrate data, we were able to determine number of taxa/station and mean number of organisms/m^2 using the techniques previously described. However, we could not calculate standard deviations since the 1975 data had been combined for each taxon at each station, instead of presented by individual replicate.

RESULTS

Benthic Invertebrates

During the July 1992 benthic invertebrate survey, 338 different organisms were identified (Appendix Table 4). Because 13 taxa were not considered benthic organisms they were eliminated from any data analysis. Number of taxa per station ranged from 11 (Station 33) to 130 (Station 36) (Table 1, Appendix Table 5). Densities ranged from 844 (Station 33) to 369,462 organisms/m^2 (Station 16). Most densities were between 5,000 and 30,000 organisms/m^2, and four stations had densities over 100,000/m^2 (Table 1). The three most abundant taxa within each major group found throughout the study area included for the polychaetes, *Spiophanes bombyx*, *Spiochaetopterus costarum*, and *Owenia fusiformis*; for the molluscs, Mytilidae (likely juveniles), *Siliqua* spp., and *Macoma* spp.; and for the crustaceans, *Diastylopsis* spp., *Diastylopsis dawsoni*, and *Diastylopsis tenuis* (Table 2).

Diversity (H) was generally high at most stations and ranged from 0.96 to 4.76, with most values greater than 2.50 (Table 1, Appendix Table 5). Equitability (E) was moderate, ranging from 0.16 to 0.76 with most values between 0.30 and 0.70. Stations with exceptionally high densities (>79,000 organisms/m^2) typically had low H and E values due to an average number of taxa and the dominance of one or more of these taxa. Stations with higher H and E values most often had a high or average number of taxa, but no taxa were numerically dominant.

Benthic invertebrate cluster groups are displayed graphically in Figure 3. Dominant species were similar among the six cluster groups; however, their densities varied greatly. The largest cluster group was composed of 17 deeper water stations with an average depth of 60 m. The second largest cluster group (eight stations) was comprised of shallow-water stations, with an average depth of 21.7 m, directly north of

Table 1.--Summary of benthic invertebrate collections offshore from the Columbia River, July 1992. Stations with one replicate have no standard deviations.

Station	Depth (m)	Number of taxa	Number of individuals/m2	Standard deviation	Diversity (H)	Equitability (E)
1	36.6	66	23,685	-	3.18	0.53
2	29.0	78	82,391	-	1.91	0.30
3	24.1	80	74,680	-	2.56	0.40
5	27.4	119	43,702	8,541	2.98	0.43
6	36.6	72	27,936	-	3.21	0.52
7	26.2	70	34,490	-	3.00	0.49
8	20.1	68	77,962	-	2.22	0.36
9	13.7	97	79,744	46,193	1.96	0.30
10	14.0	57	103,283	-	1.92	0.33
11	61.0	89	23,716	-	3.47	0.54
12	36.6	75	29,780	-	2.89	0.46
13	26.8	68	68,261	-	2.41	0.40
14	20.7	70	64,323	-	1.72	0.28
15	13.1	68	152,455	-	1.86	0.31
16	29.3	71	369,462	-	0.96	0.16
18	82.0	114	24,164	-	4.20	0.62
19	63.1	95	22,924	-	3.93	0.60
20	42.1	71	18,318	-	4.23	0.69
21	27.4	54	11,868	-	4.01	0.70
22	13.4	49	8,617	-	2.30	0.41
23	10.7	42	3,730	-	3.49	0.65
24	65.2	92	21,705	-	3.96	0.61
25	44.5	45	5,148	-	4.02	0.73
26	20.4	83	13,846	4,304	2.68	0.42
27	11.3	47	6,638	-	2.74	0.49
28	87.2	111	16,974	-	4.17	0.61
29	63.4	104	67,459	-	3.10	0.46
30	53.3	79	23,132	-	4.30	0.68
31	42.4	101	46,661	6,031	2.73	0.41
32	21.0	63	6,556	1,377	3.55	0.59
33	13.4	11	844	-	2.28	0.66
34	79.9	100	12,723	-	4.21	0.63
35	63.1	86	13,817	-	4.35	0.68
36	53.3	130	24,141	5,731	4.61	0.66
37	38.1	75	1,955	206	4.76	0.76
38	16.5	35	2,813	-	3.41	0.66
39	21.0	37	6,247	-	3.67	0.71
40	77.7	84	9,659	-	4.09	0.64
41	61.6	67	13,567	-	3.00	0.50
42	25.9	47	4,679	-	3.36	0.60
43	16.2	32	11,129	-	1.34	0.27
44	67.1	80	16,422	-	2.72	0.43
45	48.5	59	21,028	-	2.37	0.40
46	31.7	58	25,727	-	2.75	0.47
47	16.5	66	37,043	-	2.45	0.41
48	69.5	82	16,901	-	2.51	0.39
49	45.7	68	18,360	-	2.44	0.40
50	27.7	71	13,202	-	3.91	0.64
51	13.7	64	165,105	-	1.99	0.33

Table 2.--Dominant benthic invertebrates collected offshore from the Columbia River, July 1992. Data from all stations were combined.

Taxon	Mean number of individuals/m^2
Nemertea	251
Polychaeta	
Pholoe minuta	152
Phyllodoce hartmanae	164
Nephtys spp.	130
Nephtys caecoides	112
Glycinde armigera	246
Onuphidae	134
Lumbrineris luti	122
Orbiniidae	160
Polydora brachycephala	131
Prionospio lighti	153
Spiophanes bombyx	3,233
Spiophanes berkeleyorum	570
Magelona longicornis	114
Magelona sacculata	138
Trochochaeta multisetosa	161
Spiochaetopterus costarum	3,159
Chaetozone spinosa	163
Heteromastus filobranchus	210
Mediomastus spp.	341
Owenia fusiformis	11,498
Miscellaneous	1,156
TOTAL	22,247
Mollusca	
Spiromoellaria quadrae	90
Olivella pycna	132
Acila castrensis	141
Mytilidae	966
Axinopsida serricata	185
Siliqua spp.	9,016
Macoma spp.	550
Miscellaneous	380
TOTAL	11,460

Table 2.--Continued.

Taxon	Mean number of individuals/m^2
Crustacea	
Euphilomedes carcharodonta	112
Diastylopsis spp.	456
Diastylopsis dawsoni	230
Diastylopsis tenuis	350
Ampelisca macrocephala	55
Photis macinerneyi	125
Rhepoxynius spp.	63
Rhepoxynius daboius	60
Rhepoxynius vigitegus	70
Miscellaneous	402
TOTAL	1,923
Miscellaneous	
TOTAL	523
TOTAL FOR SURVEY	36,404

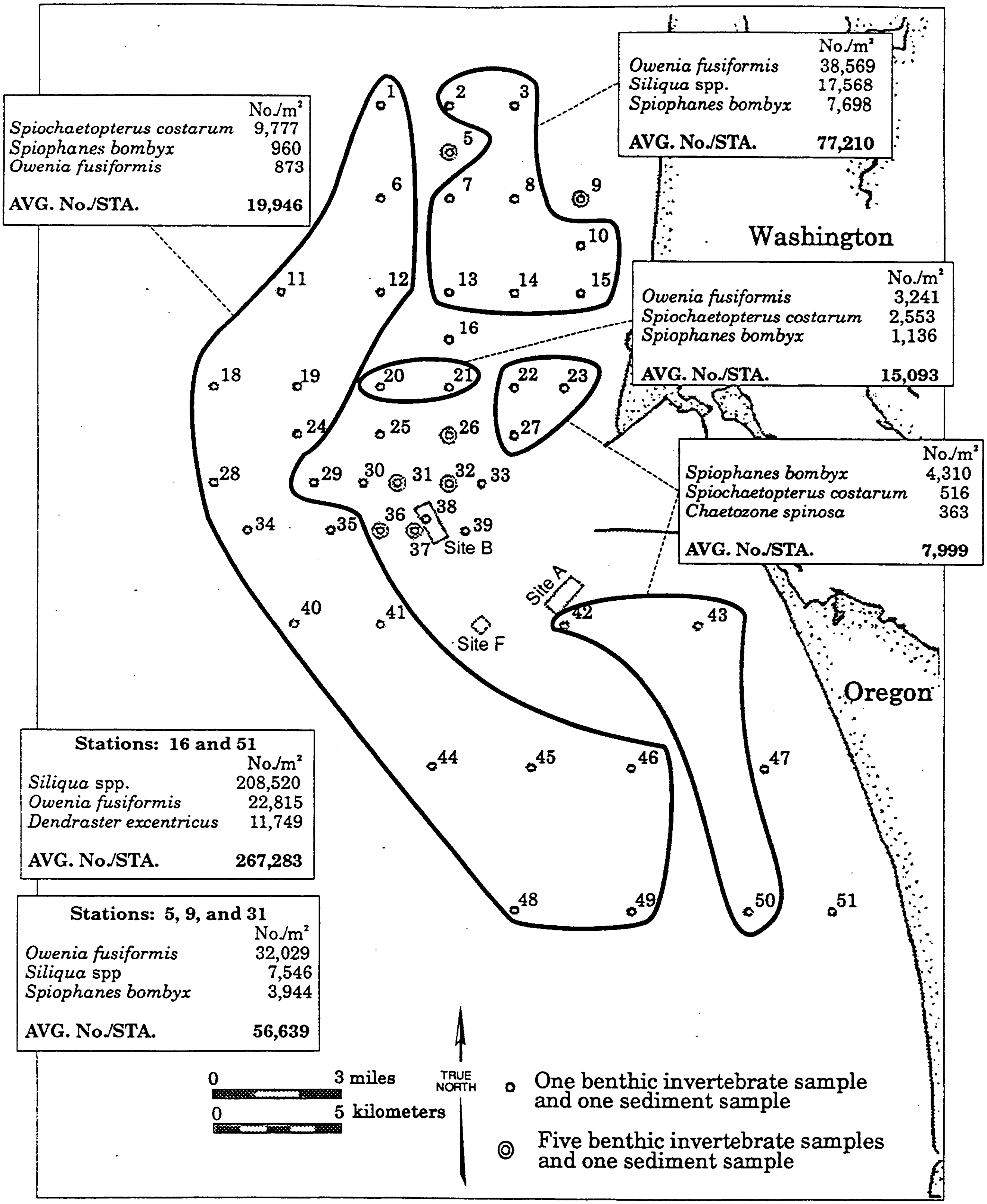

Figure 3.--Benthic invertebrate station groupings, identified using cluster analysis, and their major taxa, offshore from the Columbia River, July 1992. Sites A, B, and F are ocean dredged-material disposal sites. Average number/station (AVE. No./STA.) includes all taxa.

the mouth of the Columbia River. Immediately off the mouth of the Columbia River, 11 stations had no cluster group affiliation, indicating either a widely fluctuating habitat or many different micro-habitats.

Sediments

Physical Analyses

Fifty-two sediment samples were collected at 51 stations; 2 of the were classified as "sandy silt," 37 as "silty sand," 8 as "poorly graded sand with silt," and 5 as "poorly graded sand" (Table 3, Appendix Table 6). Less than 1.5% of the material in any of the samples was coarser than 0.25 mm (#60 sieve), a medium sand. Maximum clay content was 8.9% and 28 stations had 0.0% clay.

Percent fines (material less than 0.0625 mm) ranged from 0.30 to 48.60%. Generally percent fines increased directly with depth, both in sediments collected north and south of the mouth of the Columbia River (Appendix Fig. 2). Stations north of the mouth of the Columbia River had higher percent fines than the southern stations at similar depths.

Sediment grain size south of the mouth of the Columbia River was fairly uniform, ranging in median grain size from 0.12 to 0.18 mm. Median grain size decreased in a southerly direction (Appendix Fig. 3). Maximum median grain size was associated with the northern ebb tidal delta and ODMDS B. Northwest of ODMDS B, a distinct decreasing gradient in grain size was found. This gradient was the most pronounced feature of all physical sediment measurements. Median grain size in this area ranged from 0.06 to 0.09 mm. This area of fine-grained material forms a plume to the northwest and is bordered on the east, south, and west by coarser material (Appendix Fig. 3). The plume appears to be independent of depth contours except its association with the seaward edge of the ebb tidal delta. The plume joins the finer offshore sediments found north on the MCR

Table 3.--Sediment characteristics offshore from the Columbia River, July 1992.

Station	Depth (m)	Median grain size (mm)	Silt/clay (%)	Volatile solids (%)	Classification
1	36.6	0.09	5.5	0.9	Silty Sand
2	29.0	0.10	4.6	0.5	Silty Sand
3	24.1	0.11	3.3	0.5	Silty Sand
4	14.9	0.12	1.6	0.9	Silty Sand
5	27.4	0.10	9.1	0.9	Silty Sand
6	36.6	0.10	11.8	0.9	Silty Sand
7	26.2	0.10	4.2	0.8	Silty Sand
8	20.1	0.13	2.5	0.7	Silty Sand
9	13.7	0.14	1.1	0.8	Poorly graded sand with silt
10	14.0	0.10	3.6	1.1	Silty Sand
11	61.0	0.07	36.8	2.8	Silty Sand
12	36.6	0.09	20.7	0.8	Silty Sand
13	26.8	0.09	8.8	1.0	Silty Sand
14	20.7	0.12	5.5	0.5	Silty Sand
15	13.1	0.13	1.8	0.7	Silty Sand
16	29.3	0.08	23.2	1.0	Silty Sand
17	13.4	0.12	0.4	0.7	Silty Sand
18	82.0	0.13	20.4	6.6	Silty Sand
19	63.1	0.09	36.7	3.7	Poorly graded sand with silt
20	42.1	0.08	26.4	1.4	Poorly graded sand
21	27.4	0.09	18.4	1.3	Silty Sand
22	13.4	0.15	0.4	0.6	Silty Sand
23	10.7	0.17	0.3	4.3	Silty Sand
24	65.2	0.12	34.8	4.2	Silty Sand
25	44.5	0.08	20.4	1.5	Silty Sand
26	20.4	0.10	2.6	0.8	Silty Sand
27	11.3	0.16	0.5	0.7	Poorly graded sand with silt
28	87.2	0.15	19.1	1.8	Silty Sand
29	63.4	0.09	20.3	2.1	Silty Sand
30	53.3	0.07	45.4	3.8	Sandy Silt
31	42.4	0.06	48.6	3.7	Sandy Silt
32	21.0	0.12	9.3	1.0	Silty Sand
33	13.4	0.15	3.4	0.8	Poorly graded sand with silt
34	79.9	0.11	16.6	2.1	Silty Sand
35	63.1	0.15	17.6	2.1	Silty Sand
36	53.3	0.12	31.2	2.7	Silty Sand
37	38.1	0.18	1.2	0.8	Poorly graded sand
38	16.5	0.21	1.2	0.6	Poorly graded sand
39	21.0	0.21	4.5	0.6	Poorly graded sand with silt
39A	21.0	0.08	37.5	2.4	Silty Sand
40	77.7	0.15	15.6	2.2	Silty Sand
41	61.6	0.16	9.1	1.5	Silty Sand
42	25.9	0.17	0.5	0.5	Poorly graded sand
43	16.2	0.18	0.4	0.6	Poorly graded sand
44	67.1	0.13	7.4	1.3	Silty Sand
45	48.5	0.16	0.5	0.7	Poorly graded sand with silt
46	31.7	0.13	0.4	0.6	Poorly graded sand with silt
47	16.5	0.12	0.5	0.3	Silty Sand
48	69.5	0.14	0.8	3.0	Poorly graded sand with silt
49	45.7	0.12	5.2	1.5	Silty Sand
50	27.7	0.13	0.4	0.6	Silty Sand
51	13.7	0.12	0.3	0.7	Silty Sand

Percent volatile solids ranged from 0.3 (Station 47) to 6.6% (Station 18) (Table 3). Percent volatile solids generally increased with depth and in a northerly direction, following the same trend as the fine-grained material (Appendix Fig. 4)

Due to variations in sediment characteristics noted during sampling, two sediment samples were collected at Station 39 for physical and chemical analyses. The first grab collected a very fine-grained material, but was discarded due to contamination. The second grab (Sample #39) produced a clean sandy material (median grain size 0.21 mm, percent fines 4.5%, volatile solids 0.6%) as expected at this location and depth. The third grab at the same station produced fine-grained material, similar to the first grab. This sample was retained for benthic analysis. A fourth grab produced fine-grained material, similar to grabs 1 and 3. This sample (Sample #39A) was retained for both physical and chemical sediment analyses. Sample 39A had a median grain size of 0.08 mm, fines of 37.5%, and volatile solids of 2.4%.

Chemical Analyses

Total organic carbon (TOC) ranged from less than 0.05 (Station 43) to 1.50% (Station 31) (Appendix Table 6, Appendix Fig. 5). Appendix Table 6 also presents the results of the metal analyses. Except for mercury and silver, most stations contained quantitative amounts of the target metals. Station 11 had the highest amount of arsenic (8.50 mg/kg). The two replicate samples collected at Station 36 contained 5.60 mg/kg and 8.50 mg/kg lead. Maximum silver concentration was 0.29 mg/kg at Station 2. The organically rich fine-grained samples collected at Station 31 had the highest levels of cadmium (0.45 mg/kg), copper (21.0 mg/kg), and mercury (0.05 mg/kg), while the clean coarse-grained sample collected at Station 47 had the highest levels of nickel (32.0 mg/kg), zinc (160.0 mg/kg), and chromium (95.0 mg/kg).

PCBs were not detected in any of the 57 analyses of sediments from 51 stations.

One or more pesticides were detected at 31 of the 51 stations (Appendix Table 8). Aldrin was identified in 1 sample, dichloro-diphenyl-dichloroethane (DDD) in 1, dichloro-diphenyl-ethane (DDE) in 2, dichloro-diphenyl-trichloroethane (DDT) in 4, dieldrin in 14, and lindane in 26. Chlordane and heptachlor were undetected. Station 19 had four pesticides, DDD, DDE, dieldrin, and lindane. The maximum concentration of aldrin was 0.77 μg/kg; of DDD, 1.20 μg/kg; of DDE, 2.80 μg/kg; of DDT, 3.40 μg/kg; of dieldrin, 6.5 μg/kg; and of lindane, 3.40 μg/kg. Of the five replicate samples, pesticides were detected only at Station 37. Six method blanks (laboratory controls) were analyzed between 27 July and 7 August 1992, and the following pesticides were detected: aldrin at 0.57 μg/kg, 0.59 μg/kg, 0.6 μg/kg, and 0.71 μg/kg, and dieldrin at 2.1 μg/kg.

Of 57 analyses, samples from six stations had one or more PAHs (Appendix Table 9). Detected levels were at or near the method detection limits. All of these stations were within the finer-grained plume that runs northwest from ODMDS B. These stations also had the highest levels of TOC. During sampling, woody debris was noted in many of the samples from these stations. As with the pesticides, the largest number of contaminants, (9 out of 16) were detected at Station 19.

Contamination of sediments offshore from the Columbia River by PCDD/PCDF was not readily apparent. Selected isomers of PCDD/PCDF were identified in all 11 samples analyzed (Appendix Table 10). However, 2,3,7,8-TCDD was not detected, and 2,3,7,8-TCDF was found at Stations 28 and 37 at concentrations of 0.47 μg/kg and 0.21 μg/kg, respectively. It should be noted that trace background levels (1-13 μg/kg) of selected isomers, including 2,3,7,8-TCDF (0.06 μg/kg, method blank-806) were detected in the method blanks. Some of the levels reported for the selected isomers in the actual samples were similar to the corresponding levels found in the associated method blank. Consequently, concentrations in some samples may be partially attributed to background levels. Levels less than five times higher than background are not generally considered to be different from the background.

Fishes and Large Epibenthic Invertebrates

In the July 1992 survey, 7,186 fishes and epibenthic invertebrates were captured, representing 22 taxa (Appendix Table 11). The number and weight of fishes for the four trawls ranged from 5,240 to 11,804/ha and 34,399 to 148,170 g/ha, respectively (Table 4, Appendix Table 12). Diversity and equitability were moderate for all trawls, except for Trawl 2, which had lower values and lower densities. The lower H and E values for Trawl 2 reflected the unequal proportional abundances among the taxa that were captured, with 85% of the catch composed of Pacific tomcod (*Microgadus proximus*). Pacific tomcod was the most abundant fish in all four trawls (Table 5, Appendix Table 11).

Benthic Invertebrate Comparisons between 1975 and 1992

Richardson et al. (1977) identified 425 organisms, most to the species level (Appendix Table 13). Of those identified, 192 occurred in 1975 at the eight stations used for comparisons with 1992 data. Since eight of these taxa were not considered benthic invertebrates during the 1992 survey, they were eliminated from any analysis. For April, June, and September 1975, the number of taxa per station ranged from 22 to 89 and densities ranged from 234 to 43,802 organisms/m^2 (Table 6, Appendix Table 14).

In 1992, the number of taxa at the eight stations used for comparison were similar to those in 1975 (Table 6). For each station, densities were higher in 1992 than in 1975, except for Station 39 where densities were higher in April and June 1975 (Table 6). Benthic invertebrate densities in 1992 were expected to be higher than in 1975 due to the smaller mesh size used to sieve the samples in 1992. Mean densities in 1975 ranged from 4,390 to 6,456 organisms/m^2, whereas in 1992 the mean was 63,172 organisms/m^2.

Table 4.--Summary of fish and large epibenthic invertebrate catches for four trawling stations north of the Columbia River mouth adjacent to Peacock Spit, July 1992.

Station [depth(m)]	Number of taxa	Total fish captured	Total wt. (g)	Number/ha	Wt. (g)/ha	Diversity (H)	Equitability (E)
1 (9.4)	14	1,433	17,362	5,946	72,043	2.50	0.66
2 (12.8)	15	1,310	8,599	5,240	34,399	1.13	0.29
3 (15.5)	20	2,078	26,077	11,804	148,170	2.59	0.60
4 (18.6)	20	2,365	27,296	8,507	98,189	2.87	0.66

[a] Diversity
[b] Equitability

Table 5.--Major fish and large epibenthic invertebrates captured by bottom trawl at four stations north of the Columbia River mouth adjacent to Peacock Spit, July 1992.

Common name	Mean number/ha	Mean wt. (g)/ha
Smelt (unidentified juvenile)	523	572
Whitebait smelt	951	5,128
Pacific tomcod	3,501	24,495
California bay shrimp	539	456
Smooth bay shrimp	1,264	230
Miscellaneous taxa	1,097	57,320

Table 6.--Summary of benthic invertebrate collections for eight stations used for 1975 and 1992 comparisons, offshore from the Columbia River.

1992 Station	April 1975		June 1975		September 1975		July 1992	
	No. of taxa	No./m²	No. of taxa	No./m²	No. of taxa	No./m²	No. of taxa	No./m²
44	64	2,368	80	2,878	89	4,142	80	16,422
45	56	728	64	1,340	77	5,302	59	21,028
46	37	500	56	1,262	59	5,112	58	25,727
47	25	578	38	800	37	3,118	66	37,043
43	25	234	30	478	36	890	32	11,129
16	49	1,086	48	2,802	42	4,392	71	369,462
20	61	2,352	60	11,004	54	15,670	71	18,318
39	44	43,802	39	14,554	22	2,262	37	6,247
Mean	45	6,456	52	4,390	52	5,111	59	63,172

Few benthic invertebrates that were dominant in the 1975 surveys were dominant in the July 1992 survey (Table 7). The polychaetes *Spiophanes bombyx*, *Spiophanes berkeleyorum*, and *Magelona sacculata* were the only dominant organisms that occurred both in 1975 and 1992. Overall, the 1975 and 1992 surveys had many taxa in common, but densities of these taxa were not similar.

Table 7.--Dominant benthic invertebrates found at the eight stations used for comparisons between 1975 and 1992, offshore from the Columbia River. All values are numbers of organisms/m^2.

Taxon	1975 April	1975 June	1975 September	1992 July
Polychaeta				
Nephtys caecoides	33	37	41	219
Orbiniidae	0	0	0	310
Leitoscoloplos pugettensis	62	112	109	94
Spiophanes bombyx	22	167	1,361	2,737
Spiophanes berkeleyorum	41	75	210	654
Magelona sacculata	25	32	75	391
Spiochaetopterus costarum	1	2	2	5,805
Chaetozone setosa	24	41	59	0
Owenia fusiformis	1	<1	2	8,124
Miscellaneous	70	147	246	1,753
Mollusca				
Olivella spp.	0	0	0	77
Olivella pycna	31	20	15	26
Acila castrensis	187	175	169	59
Nucula tenuis	14	18	16	5
Axinopsida serricata	41	48	46	63
Mytilidae	0	0	0	297
Siliqua spp. (juveniles)	0	0	0	39,640
Siliqua patula	4	146	169	0
Macoma spp.	0	0	0	597
Tellina spp.	0	<1	0	63
Tellina modesta	17	22	18	9
Miscellaneous	43	59	61	166
Crustacea				
Euphilomedes carcharodonta	9	7	19	182
Diastylopsis spp.	0	0	0	149
Diastylopsis dawsoni	281	1,310	2,308	12
Tecticeps convexus	37	11	2	12
Ampelisca macrocephala	59	98	36	95
Eohaustorius sencillus	36	31	20	20
Photis macinerneyi	0	0	0	113
Protomedeia spp.	3	27	11	23
Rhepoxynius spp.	0	0	0	125
Rhepoxynius fatigans	23	43	31	0
Rhepoxynius daboius	0	0	0	142
Miscellaneous	151	172	96	412
Miscellaneous				
Amphiodia spp.	0	0	0	111
Amphiodia periercta-urtica	52	45	35	0
Echinoidea	0	0	0	353
Miscellaneous	10	18	33	333
Total for each survey	1,280	2,867	5,190	63,171

DISCUSSION

The benthic invertebrate community offshore from the Columbia River is subjected to a variety of influences: river flow, upwelling, downwelling, seasonal winds, and currents, all of which affect species diversity and densities. Benthic invertebrate composition and densities throughout the study area in July 1992 varied widely as exemplified by the cluster analysis. The largest benthic invertebrate cluster group was determined primarily by the overwhelming dominance of the polychaete *Spiochaetopterus costarum*, a tube-building surface deposit feeder. Its presence is consistent with the findings of Siipola et al. (1993) during the Tongue Point Monitoring Program, where this polychaete was the dominant organism in 1992, but was virtually non-existent in 1989-1991 at ODMDS F. Siipola et al. (1993) speculated that environmental conditions were exceptionally favorable for this organism (i.e., abundant food resources and stable substrate), resulting in excellent recruitment.

Benthic invertebrate densities at four stations during the July 1992 survey were some of the highest ever observed in Oregon and Washington coastal waters (Emmett et al. 1987; Miller et al. 1988; Emmett and Hinton 1992; Hinton and Emmett 1993; Siipola et al. 1993;). At Stations 10 (103,283 organisms/m^2), 16 (365,462 organisms/m^2) and 51 (165,105 organisms/m^2), bivalves *(Siliqua* spp.) were responsible for the high values. All the *Siliqua* spp. were recently settled juveniles. At Station 15 (152,455 organisms/m^2), the high densities were primarily due to the polychaete *Owenia fusiformis*, although unidentified mytilids and *Siliqua* spp. also contributed substantially.

The distribution of sediment types offshore from the Columbia River observed during this survey agrees with sediment distributions described in previous studies of the area (Kulm et al. 1975, Sternberg et al. 1977). South of the entrance to the Columbia River, sediment grain size decreases with increasing depth, as expected.

The zone of organically enriched fine-grained sediments to the west and northwest of ODMDS B found in this survey was described by Sternberg et al. (1977):

> "Immediately west of Disposal Site B both the clay- and silt-size fractions constituted abnormally greater proportions of the bottom samples as compared to samples from equivalent depths to the south. A narrow zone of high clay content sediments trends north-northwest to join the area of higher than normal offshore concentrations. The bottom sediments north of Disposal Site B had a high concentration of silt-size particles and in combination with the high silt content sediments west of the disposal site formed the southeastern end of a lobe of high silt content sediment that trended northwest from Site B."

Kulm et al. (1975) stated that the Cascadia Channel receives sediment from the Columbia River through the Willapa Canyon, which has its head on the outer edge of the continental shelf 45 km north of the mouth of the Columbia River. A northwest offshore transport of coarse silt and very fine sand is required to supply Willapa Canyon with sediment for periodic submarine slumps. Radionuclide studies of fine-grained, river-borne particulate matter in the shelf sediments derived from the Columbia River show a net northward and westward transport toward the vicinity of Willapa Canyon. The same net transport is indicated by near-bottom current studies.

Sediments south of the mouth of the Columbia River appear unchanged from material collected by Sternberg et al. (1977). Median grain size ranged from fine sand (0.15 mm) to very fine sand (0.11 mm) in the Sternberg et al. study, while during our preliminary study, the median grain size ranged from 0.16 to 0.12 mm. Sternberg et al. (1977) noted that this area showed little seasonal change during their sampling survey. Sediment characteristics at other areas were more dynamic, especially around the mouth of the river.

One interesting observation made during our survey was the range of material collected during successive grab samples at Station 39. This station is located east of ODMDS B on the ebb tidal delta in 21 m of water. The first sample had a median grain size of 0.21 mm (fine sand) and 4.5% fines; the second sample had a median grain size of

0.08 mm (very fine sand) and 37.5% fines. Sternberg et al. (1977) noted similar dissimilarities in samples collected the same day, but at different times (1 hour and 14 minutes apart) and "supposedly at the same location", their Station 27 was located in 30 m of water southeast of ODMDS B--1,853 m south and 640 m east of our study's Station 39.

Annual variations in sediment characteristics were noted at Station G1 during the Tongue Point Monitoring Program (Siipola et al. 1993). This station is directly north of ODMDS F and southeast of ODMDS B and is within navigational or coordinate computational error and should be considered the same location as Sternberg et al.'s (1977) Station 27. Percent fines at Station G1 in 1990, 1991, and 1992 were 1.2, 19.6, and 0.8%, respectively. These variations are independent of any dredged-material disposal event. The origin, fate, and significance of these transitory fine-grained deposits are unknown.

Significant chemical contamination offshore from the Columbia River was not observed. Heavy-metal concentrations were typical of uncontaminated offshore sediments. Higher heavy-metal concentrations should be found in areas of naturally occurring black sand, but were not evident in the present data. No PCBs were detected in any of the sediments, and PAH concentrations, when detected, were low and probably from natural sources. Woody debris was noted in many samples where the PAHs were detected. Pesticides were detected more frequently than other potential contaminants, but many of the concentrations were near method-detection levels.

Fish species captured by trawling north of the mouth of the Columbia River in 1992 were similar to those found in previous surveys in other areas offshore from the Columbia River (Durkin and Lipovsky 1977; Siipola et al. 1993). However, fish densities varied greatly among surveys, which most likely is related to the different study locations.

This project provided an excellent example of the difficulties and limitations of comparing historical and recent benthic invertebrate surveys. The lack of historical raw benthic invertebrate data and changes in sampling techniques and timing of sampling restricted our ability to perform statistical comparisons between data collected in 1975 and 1992. This difficulty also exemplifies the need for long-term monitoring to permit an accurate description of benthic invertebrate populations and to help discern annual variations from environmental impacts. For example, benthic invertebrate densities at ODMDS F essentially doubled during each survey from 1989 to 1992 (Siipola et al. 1993). This event would have been undetectable with a short-term study.

It is difficult to draw any definitive conclusion concerning benthic invertebrate community structure offshore from the Columbia River from a single sample at each station. However, our goal was to provide a general description of the benthic invertebrate community and sediment structure in the nearshore area around the mouth of the Columbia River, and to identify areas where deposition of dredged material would apparently cause the least environmental damage. As a result of the 1992 benthic invertebrate survey, benthic sampling was conducted in July 1993 directly west and south of the mouth of the Columbia River, an area of generally lower benthic invertebrate densities. The 1993 survey should help identify variations in the benthic invertebrate community offshore from the Columbia River and further identify areas best suited for dredged-material disposal. The 1993 information is expected in spring 1994.

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CITATIONS

Carey, A. G., Jr., and H. Heyamoto. 1972. Techniques and equipment for sampling benthic organisms. *In* A. T. Pruter and D. L. Alverson (editors), The Columbia River and adjacent ocean waters, bioenvironmental studies, 378-408 p. Univ. Washington Press, Seattle.

Clifford, H. T., and W. Stephenson. 1975. An introduction to numerical classification. Academic Press, Inc., New York. 229 p.

Durkin, J. T., and S. Lipovsky. 1977. Aquatic disposal field investigations Columbia River disposal site, Oregon. Appendix E: Demersal fish and decapod shellfish studies. U.S. Army Corps of Engineers Tech. Rep. D-77-30, 159 p. plus appendices. (Available from Waterways Experiment Station, P.O. Box 631, Vicksburg, MS 39180.)

Emmett, R. L., T. C. Coley, G. T. McCabe, Jr., and R. J. McConnell. 1987. Demersal fishes and benthic invertebrates at four interim dredge disposal sites off the Oregon coast. Report to U.S. Army Corps of Engineers, Contract DACW57-85-F-0210, 69 p. plus appendices. (Available from Northwest Fisheries Science Center, 2725 Montlake Boulevard East, Seattle, WA 98112.)

Emmett, R. L., and S. A. Hinton. 1992. Benthic and epibenthic invertebrates, demersal fishes, and sediment structure off Tillamook Bay, Oregon, September 1990, with comparisons to previous surveys. Report to the U.S. Army Corps of Engineers, Contract E96900022, 25 p. plus appendices. (Available from Northwest Fisheries Science Center, 2725 Montlake Boulevard East, Seattle, WA 98112.)

Hinton, S. A., and R. L. Emmett. 1993. Demersal fishes, benthic and epibenthic invertebrates, and sediment characteristics, at and adjacent to offshore disposal site F, Coos Bay, Oregon, April and October 1992. Report to the U.S. Army Corps of Engineers, Contracts E69620027 and E96920028, 25 p. plus appendices. (Available from Northwest Fisheries Science Center, 2725 Montlake Boulevard East, Seattle, WA 98112.)

Krebs, C. J. 1978. Ecology: the experimental analysis of distribution and abundance. Harper and Row. NewYork. 678 p.

Kulm, L. D., R. C. Roush, J. C. Harlett, R. H. Neudeck, D. M. Chambers, and E. J. Runge. 1975. Oregon continental shelf sedimentation: interrelationships of facies distribution and sedimentary process. J. Geol. 83:145-175.

Miller, D. R., R. L. Emmett, and R. J. McConnell. 1988. Benthic invertebrates and demersal fishes at an interim dredge-disposal site off Willapa Bay, Washington. Report to the U.S. Army Corps of Engineers, Contract DW-13931463-01-0, 20 p. plus appendices. (Available from U.S. Army Corps of Enginners, Portland District, P.O. Box 2946, Portland, OR 97208.)

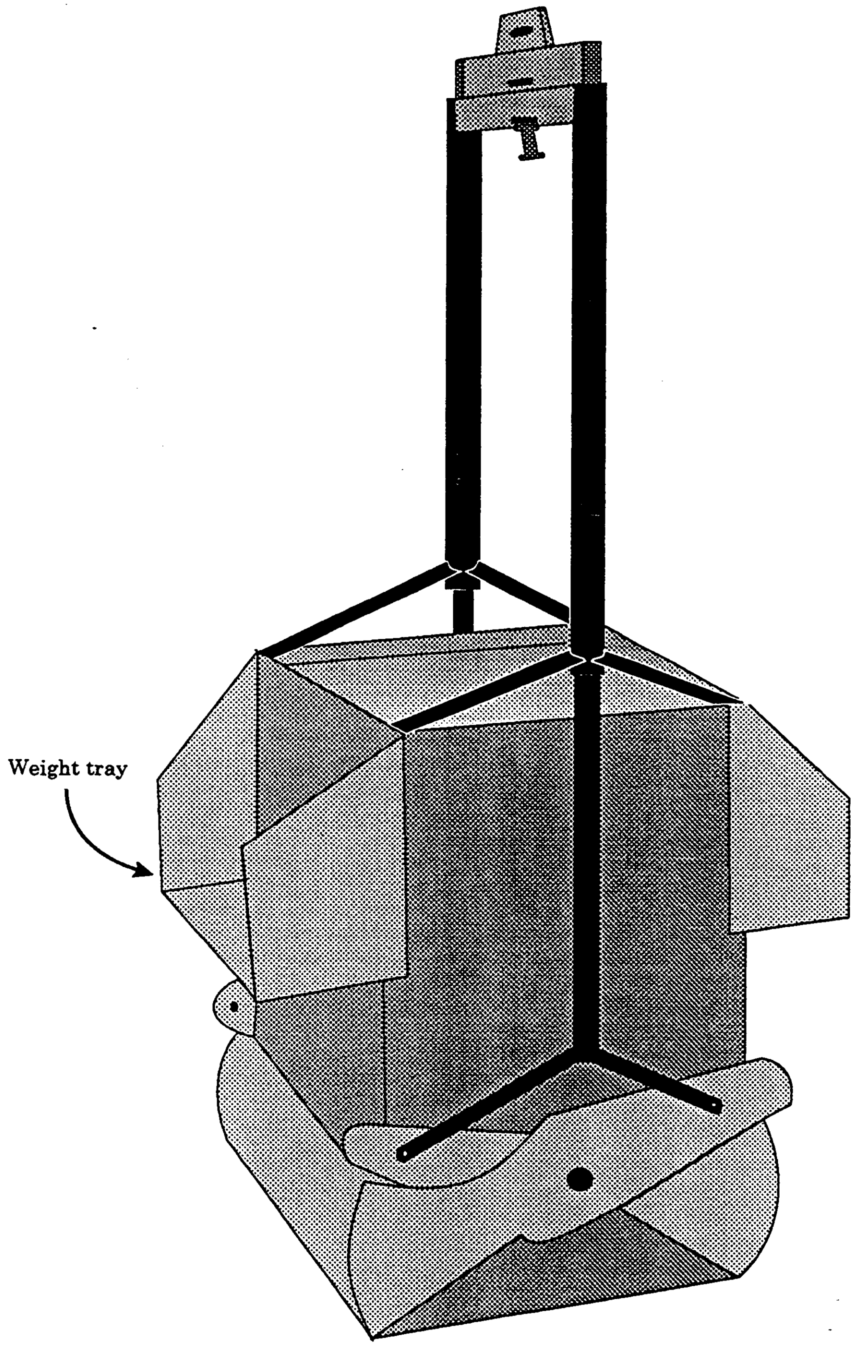
Pequegnat, W. E., L. H. Pequegnat, P. Wilkinson, J. S. Young, and S. L. Kiessger. 1981. Procedural guide for designation surveys of ocean dredged material disposal sites. U. S. Army Corps of Engineers Tech. Rep. EL-81-1, 268 p. plus appendices.

Richardson, M. D., A. G. Carey, and W. A. Colgate. 1977. Aquatic disposal field investigations Columbia River disposal site, Oregon. Appendix C: The effects of dredged material disposal on benthic assemblages. Report to U.S. Army Corps of Engineers, Contract DACW57-C0040, 65 p. plus appendices. (Available from Waterways Experiment Station, P.O Box 631, Vicksburg, MS 39180.)

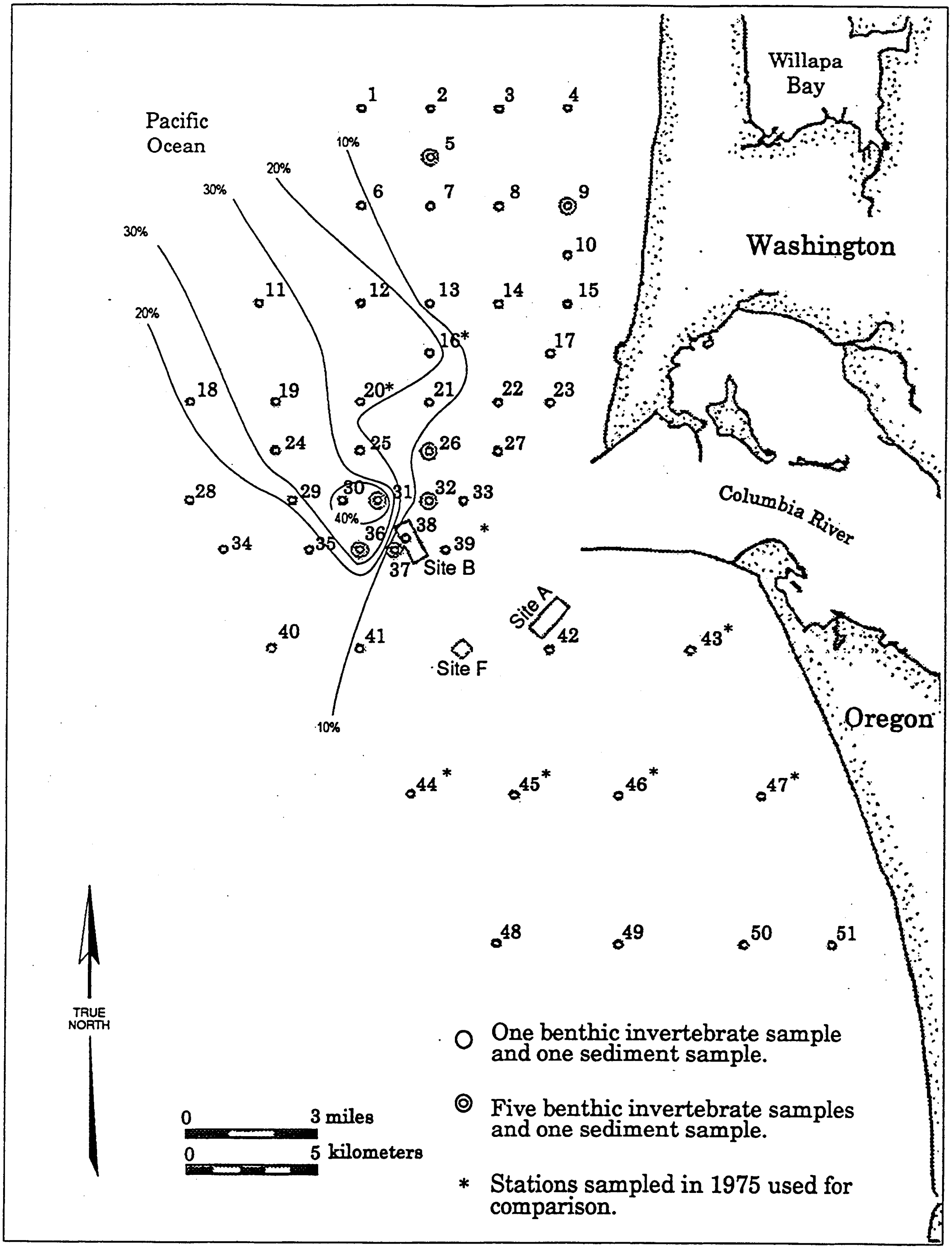
Siipola, M. D., R. L. Emmett, and S. A. Hinton. 1993. Tongue Point Monitoring Program 1989-1992 final report. Report to U.S. Army Corps of Engineers, Contract E96910024 and E96910025, 63 p. plus appendices. (Available from U. S. Army Corps of Engineers, Portland District, P.O. Box 2946, Portland, OR 97208.)

Sternberg, W. R., J. S. Creager, W. Glassley, and J. Johnson. 1977. Aquatic disposal field investigations Columbia River disposal site, Oregon. Appendix A: Investigation of the hydraulic regime and physical nature of bottom sedimentation, final report. Report to U.S. Army Corps of Engineers, Contract DACW57-79-C0041, 327 p. plus appendices. (Available from Waterways Experiment Station, P.O. Box 631, Vicksburg, MS 39180.)

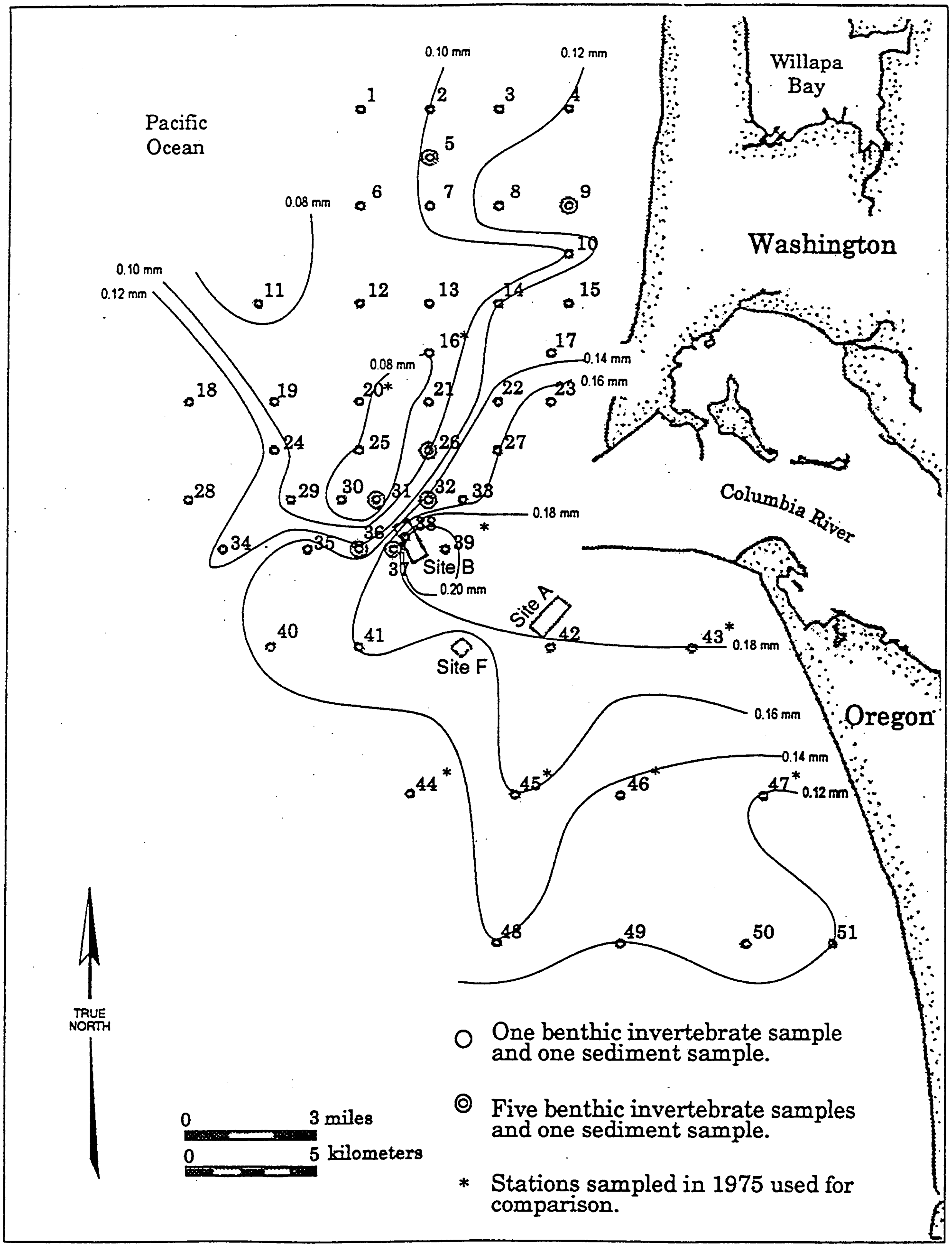
APPENDIX FIGURES



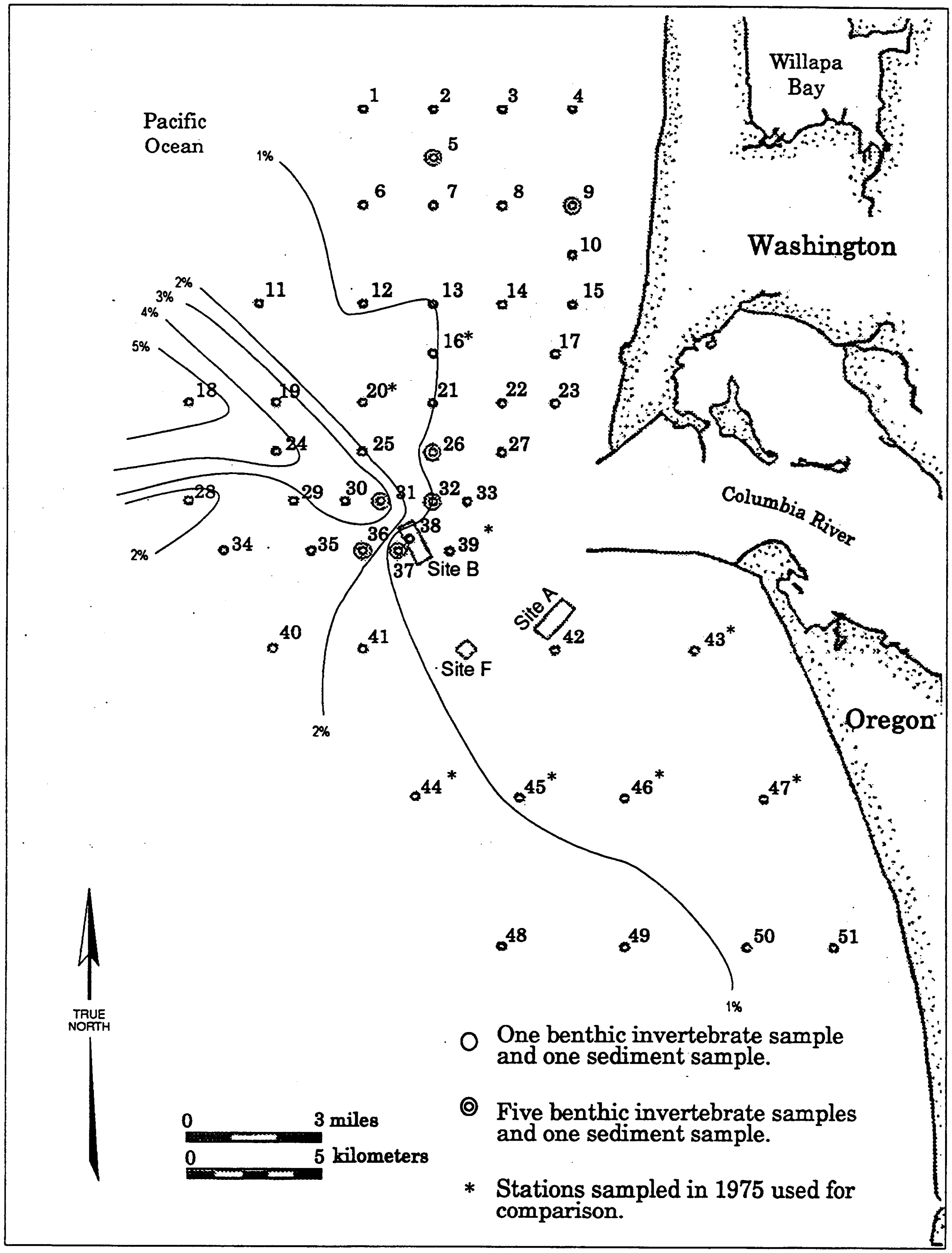
Appendix Figure 1.--The 0.1-m^2 box corer (Gray-O'Hara modification of a standard box corer) used for benthic invertebrate sampling offshore from the Columbia River, Oregon, July 1992. For deeper penetration 113 kg (250 lb) weights were placed in each tray located on opposite sides of the sampler.



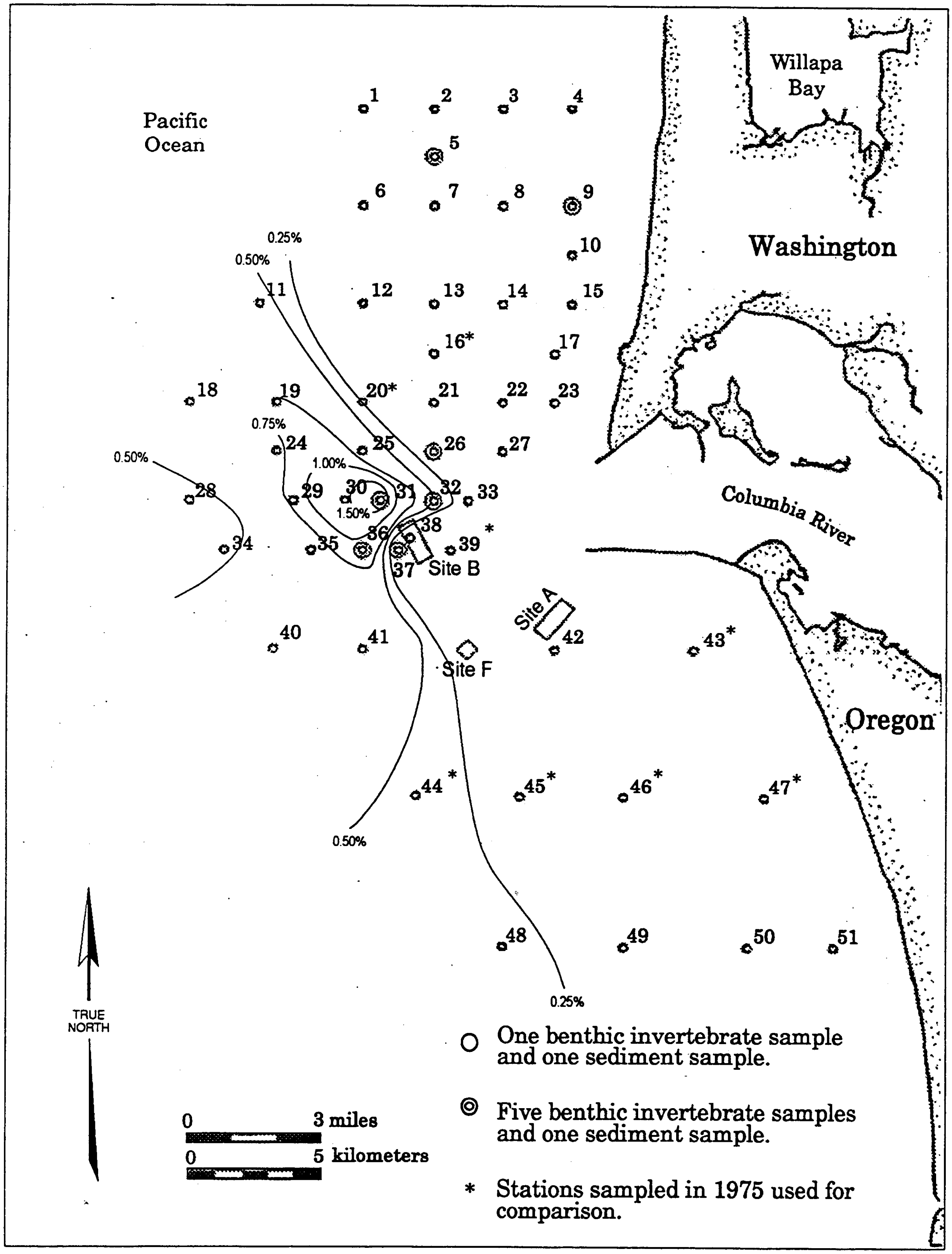
Appendix Figure 2.--Percent of fine-grain material (<0.0625) found offshore from the Columbia River, July 1992. Sites A, B, and F are ocean dredged material disposal sites.



Appendix Figure 3.--Mean grain size (mm) found offshore from the Columbia River, July 1992. Sites A, B, and F are ocean dredged material disposal sites.



Appendix Figure 4.--Percent volatile solids found offshore from the Columbia River, July 1992. Sites A, B, and F are ocean dredged-material disposal sites.



Appendix Figure 5.--Percent total organic carbon (TOC) found offshore from the Columbia River, July 1992. Sites A, B, and F are ocean dredged-material disposal sites.

APPENDIX TABLES

Appendix Table 1.--Locations of benthic invertebrate, sediment, and trawling stations offshore from the Columbia River, July 1992.

BENTHIC INVERTEBRATE AND SEDIMENT LOCATIONS

Station	Date	DMRP No.[a]	Depth m (ft)	Latitude	Longitude
1	15 Jul		36.6 (120)	46° 23.0'N	124° 12.0'W
2	15 Jul		29.0 (95)	46° 23.0	124° 10.0
3	15 Jul		24.1 (79)	46° 23.0	124° 8.0
4	15 Jul		14.9 (49)	46° 23.0	124° 6.0
5	20 Jul		27.4 (90)	46° 22.0	124° 10.0
6	20 Jul		36.6 (120)	46° 21.0	124° 12.0
7[b]	20 Jul		26.2 (86)	46° 21.0	124° 10.0
8	20 Jul		20.1 (66)	46° 21.0	124° 8.0
9	20 Jul		13.7 (45)	46° 21.0	124° 6.0
10	20 Jul		14.0 (46)	46° 20.0	124° 6.0
11	20 Jul	150	61.0 (200)	46° 19.0	124° 15.0
12	20 Jul	151	36.6 (120)	46° 19.0	124° 12.0
13	20 Jul	152	26.8 (88)	46° 19.0	124° 10.0
14	20 Jul		20.7 (68)	46° 19.0	124° 8.0
15	20 Jul		13.1 (43)	46° 19.0	124° 6.0
16	20 Jul	145	29.3 (96)	46° 18.0	124° 10.0
17[b]	20 Jul	98	13.4 (44)	46° 18.0	124° 6.5
18	20 Jul	144	82.0 (269)	46° 17.0	124° 17.0
19	20 Jul	143	63.1 (207)	46° 17.0	124° 14.5
20	20 Jul	142	42.1 (138)	46° 17.0	124° 12.0
21	20 Jul	141	27.4 (90)	46° 17.0	124° 10.0
22	20 Jul		13.4 (44)	46° 17.0	124° 8.0
23	20 Jul	149	10.7 (35)	46° 17.0	124° 6.5
24	20 Jul	99	65.2 (214)	46° 16.0	124° 14.5
25	20 Jul	100	44.5 (146)	46° 16.0	124° 12.0
26	20 Jul	101	20.4 (67)	46° 16.0	124° 10.0
27	20 Jul	102	11.3 (37)	46° 16.0	124° 0.8
28	27 Jul	97	87.2 (286)	46° 15.0	124° 17.0
29	27 Jul	96	63.4 (208)	46° 15.0	124° 14.0
30	27 Jul		53.3 (175)	46° 15.0	124° 12.5
31	27 Jul	95	42.4 (139)	46° 15.0	124° 11.5
32	27 Jul	103	21.0 (69)	46° 15.0	124° 10.0
33	27 Jul	94	13.4 (44)	46° 15.0	124° 9.0
34	27 Jul	67	79.9 (262)	46° 14.0	124° 16.0
35	27 Jul	66	63.1 (207)	46° 14.0	124° 13.5
36	27 Jul		53.3 (175)	46° 14.0	124° 12.0
37	27 Jul	65	38.1 (125)	46° 14.0	124° 11.0
38	27 Jul	117	16.5 (54)	46° 14.3	124° 10.7
39	27 Jul	64	21.0 (69)	46° 14.0	124° 9.5
40	22 Jul	55	77.7 (255)	46° 12.0	124° 14.6
41	22 Jul	56	61.6 (202)	46° 12.0	124° 12.0
42	22 Jul	58	25.9 (85)	46° 12.0	124° 6.5
43	22 Jul	59	16.2 (53)	46° 12.0	124° 2.5
44	22 Jul	53	67.1 (220)	46° 9.0	124° 10.5
45	22 Jul	52	48.5 (159)	46° 9.0	124° 7.5
46	22 Jul	51	31.7 (104)	46° 9.0	124° 4.5
47	22 Jul	60	16.5 (54)	46° 9.0	124° 0.5
48	22 Jul	48	69.5 (228)	46° 6.0	124° 8.0
49	22 Jul	49	45.7 (150)	46° 6.0	124° 4.5
50	22 Jul	50	27.7 (91)	46° 6.0	124° 1.0
51	22 Jul	61	13.7 (45)	46° 6.0	123° 58.5

[a] Dredged Material Research Program (DMRP) identification number from 1975-1977 surveys.

[b] Benthic invertebrate sample destroyed, not used in any analysis.

Appendix Table 1.--Continued.

TRAWLING LOCATIONS

Station	Mean depth m (ft)	Loran-C readings Beginning		Ending	
1	9.4 (31)	12064.6	28033.6	12062.8	28033.8
2	12.8 (42)	12063.1	28023.3	12061.1	28032.8
3	15.8 (52)	12059.6	28032.2	12058.2	28032.5
4	18.6 (61)	12057.0	28031.7	12054.8	28032.1

Appendix Table 2.--Stations (locations and numbers) for April, June, and September 1975 and July 1992 which were used for comparisons, offshore from the Columbia River.

		1975 Station numbers			1992 Station numbers
Latitude	Longitude	April	June	September	July
46° 9.0′N	124° 10.5′W	160	209	284	44
9.0′	7.5′	161	208	285	45
9.0′	4.5′	162	207	286	46
9.0′	0.5′	163	206	271	47
12.0′	2.5′	164	203	272	43
18.0′	10.0′	168	215	287	16
17.0′	12.0′	169	214	288	20
14.0′	9.5′	178	189	277	39

Appendix Table 3.--Analytical methods and method detection limits (MDL) for metals and organics used on sediment samples collected offshore from the Columbia River, July 1992.

	MDL	EPA Methods
Metals (mg/kg)		
Arsenic (As)	0.1	3050/7060
Cadmium (Cd)	0.02	3050/7131
Chromium (Cr)	0.6	3050/6010
Copper (Cu)	0.2	3050/6010
Lead (Pb)	2.0	3050/6010
Mercury (Hg)	0.02	7470
Nickel (Ni)	1.0	3050/6010
Zinc (Zn)	0.2	3050/6010
Silver (Ag)	0.02	3050/7760
Organics (µg/kg)		
LPAH	20.0	3550/8270
HPAH	20.0	3550/8220
Pesticides	1.7-6.7	3540/8080
PCBs	10-58	3540/8080
TCDD/TCDF (pg/kg)	<1.0	8290 (modified)

Appendix Table 4.--Epibenthic and benthic invertebrate taxa collected by box corer offshore from the Columbia River, July 1992.

Taxon	July 1992
Anthozoa	x
Pleurobrachidae	x
Platyhelminthes	x
Nemertea	x
Polychaeta	x
Aphroditidae	
Aphrodita spp.	x
Polynoidae	x
Gattyana treadwelli	x
Hesperone complanata	x
Lepidasthenia berkeleyae	x
Enipo canadensis	x
Tenonia priops	x
Sigalionidae	x
Pholoe minuta	x
Sthenelais berkeleyi	x
Sthenelais tertiaglabra	x
Sigalion mathildae	x
Phyllodocidae	x
Eteone spp.	x
Eteone fauchaldi	x
Eteone longa	x
Eulalia spp.	x
Phyllodoce spp.	x
Phyllodoce groenlandica	x
Phyllodoce hartmanae	x
Paranaitides polynoides	x
Eumida spp.	x
Eumida sanguinea	x
Hesionidae	x
Microphthalmus sczelkowii	x
Heteropodarke heteromorpha	x
Podarke pugettensis	x
Podarkeopsis glabrus	x
Pilargidae	
Sigambra bassi	x
Pilargis berkeleyae	x
Parandalia fauveli	x
Syllidae	x
Proceraea cornutus	x
Syllis alternata	x
Syllis elongata	x
Exogone gemmifera	x
Sphaerosyllis brandhorsti	x
Ehlersia heterochaeta	x
Nereidae	x
Nereis spp.	x
Nereis zonata	x

Appendix Table 4.--Continued.

Taxon	July 1992
Nephtyidae	x
Nephtys spp.	x
Nephtys caeca	x
Nephtys cornuta cornuta	x
Nephtys rickettsi	x
Nephtys ferruginea	x
Nephtys californiensis	x
Nephtys caecoides	x
Nephtys signifera	x
Sphaerodoridae	
Sphaerodoropsis minuta	x
Sphaerodoropsis spaerulifer	x
Glyceridae	
Glycera spp.	x
Glycera americana	x
Glycera robusta	x
Glycera convoluta	x
Glycera nana	x
Glycinde spp.	x
Glycinde armigera	x
Glycinde picta	x
Goniadidae	
Goniada brunnea	x
Onuphidae	x
Onuphis spp.	x
Onuphis iridescens	x
Lumbrineridae	x
Lumbrineris spp.	x
Eranno bicirrata	x
Lumbrineris luti	x
Lumbrineris cruzensis	x
Ninoe gemmea	x
Arabellidae	
Drilonereis nuda	x
Dorvilleidae	x
Orbiniidae	x
Scoloplos armiger	x
Leitoscoloplos pugettensis	x
Orbinia (Phylo) *felix*	x
Paraonidae	
Aedicira pacifica	x
Aricidea spp.	x
Aricidea (=Acesta) catherinae	x
Aricidea ramosa	x
Aricidea (=Acesta) pacifica	x
Paraonella platybranchia	x
Levinsenia gracilis	x
Apistobrachidae	
Apistobranchus ornatus	x
Spionidae	x
Laonice cirrata	x
Polydora spp.	x
Polydora socialis	x
Polydora brachycephala	x
Polydora cardalia	x
Prionospio pinnata	x
Prionospio steenstrupi	x

Appendix Table 4.--Continued.

Taxon	July 1992
Prionopsio lighti	x
Spio spp.	x
Spio filicornis	x
Spio butleri	x
Boccardia pugettensis	x
Spiophanes spp.	x
Spiophanes bombyx	x
Spiophanes berkeleyorum	x
Paraprionospio pinnata	x
Scolelepis spp.	x
Scolelepis squamata	x
Scolelepis foliosa	x
Magelonidae	
Magelona spp.	x
Magelona longicornis	x
Magelona berkeleyi	x
Magelona sacculata	x
Magelona hobsonae	x
Trochochaetidae	
Trochochaeta spp.	x
Trochochaeta multisetosa	x
Chaetopteridae	x
Spiochaetopterus spp.	x
Spiochaetopterus costarum	x
Mesochaetopterus taylori	x
Cirratulidae	x
Cirratulus cirratus	x
Aphelochaeta spp.	x
Aphelochaeta multifilis	x
Aphelochaeta secunda	x
Chaetozone spp.	x
Chaetozone spinosa	x
Cossura spp.	x
Cossura longocirrata	x
Cossura pygodactylata	x
Flabelligeridae	x
Flabelligera affinis	x
Scalibregmidae	
Asclerocheilus beringianus	x
Opheliidae	x
Ophelina acuminata	x
Armandia brevis	x
Ophelia spp.	x
Travisia spp.	x
Travisia japonica	x
Sternapsidae	
Sternapsis scutata	x
Capitellidae	x
Capitella capitata complex	x
Heteromastus filiformis	x
Heteromastus filobranchus	x
Notomastus tenuis	x
Notomastus lineatus	x
Mediomastus spp.	x
Mediomastus californiensis	x
Decamastus gracilis	x
Barantolla americana	x

Appendix Table 4.--Continued.

Taxon	July 1992
Arenicolidae	
Arenicola marina	x
Maldanidae	x
Asychis spp.	x
Maldane glebifex	x
Praxillella gracilis	x
Rhodine biforquata	x
Euclymene spp.	x
Euclymene zonalis	x
Oweniidae	
Owenia fusiformis	x
Myriochele heeri	x
Galathowenia oculata	x
Pectinaridae	
Pectinaria spp.	x
Pectinaria granulata	x
Pectinaria californiensis	x
Ampharetidae	x
Ampharete spp.	x
Ampharete acutifrons	x
Terebellidae	x
Pista brevibranchiata	x
Pista estevanica	x
Polycirrus spp. complex	x
Lanassa venusta venusta	x
Terebellides stroemi	x
Sabellidae	x
Chone dunneri	x
Euchone incolor	x
Euchone hancocki	x
Oligochaeta	x
Gastropoda	x
Turbinidae	
Spiromoellaria quadrae	x
Cerithiidae	
Bittium spp.	x
Epitoniidae	
Epitonium spp.	x
Naticidae	
Polinices spp.	x
Muricidae	
Urosalpinx cinereus	x
Nitidella gouldi	x
Nassariidae	
Nassarius spp.	x
Nassarius mendicus	x
Nassarius fossatus	x
Olivelidae	
Olivella spp.	x
Olivella biplicata	x
Olivella baetica	x
Olivella pycna	x
Turridae	
Oenopota spp.	x
Kurtziella plumbea	x

Appendix Table 4.--Continued.

Taxon	July 1992
Pyramidellidae	
Odostomia spp.	x
Turbonilla spp.	x
Schaphandridae	
Acteocina culcitella	x
Cylichna attonsa	x
Scaphander willetti	x
Aglajidae	
Melanochlamys diomedea	x
Gastropteridae	
Gastropteron pacificum	x
Corambidae	
Corambe pacifica	x
Aplacophora	x
Pelecypoda	x
Nuculidae	
Acila castrensis	x
Nucula tenuis	x
Yoldia spp.	x
Yoldia scissurata	x
Mytilidae	x
Megacrenella columbiana	x
Musculus spp.	x
Thyasiridae	
Axinopsida serricata	x
Thyasira gouldi	x
Montacutidae	
Neaeomya rugifera	x
Mysella tumida	x
Carditidae	
Cyclocardia ventricosa	x
Cardiidae	
Clinocardium spp.	x
Cultellidae	
Siliqua spp.	x
Siliqua patula	x
Siliqua sloati	x
Solen sicarius	x
Tellinidae	
Macoma spp.	x
Macoma calcarea	x
Macoma nasuta	x
Macoma balthica	x
Tellina spp.	x
Tellina nuculoides	x
Tellina carpenteri	x
Tellina modesta	x
Tellina bodegensis	x
Veneridae	
Compsomyax subdiaphana	x
Hiatellidae	
Hiatella arctica	x
Thraciidae	
Thracia trapezoides	x

Appendix Table 4.--Continued.

Taxon	July 1992
Scaphopoda	x
Cadulus spp.	x
Gadilidae	x
Crustacea	
Ostracoda	x
Cylindroleberididae	x
Cyprinidae	
Euphilomedes spp.	x
Euphilomedes carcharodonta	x
Calanoida (Copepoda)	x
Harpacticoida (Copepoda)	x
Cyclopoida (Copepoda)	x
Corycaeus spp.	x
Cirripedia	x
Nebaliidae	
Nebalia pugettensis	x
Mysidae	
Acanthomysis spp.	x
Acanthomysis columbiae	x
Archaeomysis grebnitzkii	x
Neomysis spp.	x
Lampropidae	x
Hemilamprops californica	x
Leuconidae	
Leucon spp.	x
Diastylidae	x
Diastylis spp.	x
Diastylopsis spp.	x
Diastylopsis dawsoni	x
Diastylopsis tenuis	x
Colurostylidae	
Colurostylis occidentalis	x
Nannastacidae	
Cumella vulgaris	x
Tanaidae	
Pseudotanais occulatus	x
Paratanaidae	
Leptognathia gracilis	x
Isopoda	
Sphaeromatidae	
Tecticeps convexus	x
Gnorimosphaeroma oregonensis	x
Ancinus spp.	x
Idoteidae	
Synidotea spp.	x
Synidotea angulata	x
Munnidae	
Munna spp.	x
Amphipoda	x
Gammaridea	x
Ampeliscidae	
Ampelisca spp.	x
Ampelisca macrocephala	x
Ampelisca careyi	x

Appendix Table 4.--Continued.

Taxon	July 1992
Aoroidae	
Aoroides spp.	x
Atylidae	
Atylus tridens	x
Corophiidae	
Corophium spp.	x
Corophium spinicorne	x
Gammaridae	
Maera spp.	x
Haustoridae	
Eohaustorius spp.	x
Eohaustorius washingtonianus	x
Eohaustorius estuarius	x
Eohaustorius sencillus	x
Hyalidae	
Parallorchestes spp.	x
Isaedae	
Photis spp.	x
Photis macinerneyi	x
Photis parvidons	x
Protomedeia spp.	x
Protomedeia articulata	x
Podoceropsis spp.	x
Lysianassidae	x
Orchomene spp.	x
Orchomene pacifica	x
Orchomene pinquis	x
Pachynus c.f. *barnardi*	x
Psammonyx longimerus	x
Oedicerotidae	
Monoculodes spp.	x
Synchelidium shoemakeri	x
Westwoodilla caecula	x
Phoxocephalidae	
Mandibulophoxus gilesi	x
Rhepoxynius spp.	x
Rhepoxynius abronius	x
Rhepoxynius daboius	x
Rhepoxynius vigitegus	x
Foxiphalus major	x
Pleustidae	
Parapleustes spp.	x
Parapleustes pugettensis	x
Podocerus spp.	x
Stenothoidae	x
Decapoda	
Decapoda zoea	x
Caridea	x
Caridea zoea	x
Crangonidae	
Crangon spp.	x
Crangon nigricauda	x
Lissocrangon stylirostris	x
Callianassidae	
Callianassa californiensis	x
Paguridae	
Pagurus spp.	x

Appendix Table 4.--Continued.

Taxon	July 1992
Brachyura	
Brachyura zoea	x
Cancridae	
Cancer spp.	x
Cancer magister	x
Pinnotheridae	
Pinnixa spp.	x
Pinnixa eburna	x
Aphididae	x
Collembola	x
Sipunculidae	x
Echiurida	x
Phoronida	x
Brachiopoda	x
Asteroidea	x
Ophiuroidea	x
Ophiura spp.	x
Amphiuridae	x
Amphiodia spp.	x
Amphiura spp.	x
Echinoidea	x
Dendraster excentricus	x
Holothuroidea	x
Pentamera spp.	x
Chaetognatha	x
Total number of taxa/categories identified	338

Appendix Table 5.--Summaries of benthic invertebrate collections by station, offshore from the Columbia River, July 1992 (available upon request from National Marine Fisheries Service, Point Adams Biological Field Station, P.O. Box 155, Hammond, OR 97121).

Appendix Table 6.--Summary of sediment physical analyses by station, offshore from the Columbia River, July 1992.

Station no.	Grain Size		Grain Size Distribution							TOC	Volital Solids	ASTM D 2487
	Mean (mm)	Median (mm)	V Coarse sand	Coarse Sand	Medium Sand	Fine Sand (%<)	Vf Sand (%<)	Silt (%<)	Clay (%)	%	%	Classification
1	0.10	0.09	100.00	100.00	99.80	99.6	75.6	5.5	0.0	0.14	0.90	SM Silty Sand
2	0.11	0.10	100.00	100.00	100.00	99.8	64.3	4.6	0.0	0.10	0.50	SM Silty Sand
3	0.12	0.11	100.00	100.00	100.00	99.6	58.2	3.3	0.0	0.10	0.50	SM Silty Sand
4	0.13	0.12	100.00	100.00	99.80	99.5	54.3	1.6	0.0	0.21	0.90	SM Silty Sand
5	0.11	0.10	100.00	100.00	99.60	99.3	66.4	9.1	0.0	0.11	0.90	SM Silty Sand
6	0.11	0.10	100.00	100.00	100.00	99.9	72.1	11.8	0.9	0.11	0.90	SM Silty Sand
7	0.12	0.10	100.00	100.00	99.90	99.5	62.9	4.2	0.0	0.10	0.80	SM Silty Sand
8	0.14	0.13	100.00	100.00	99.90	98.8	49.7	2.5	0.0	0.10	0.70	SM Silty Sand
9	0.15	0.14	100.00	100.00	99.80	99.2	39.7	1.1	0.0	0.10	0.80	SP-SM Poorly graded Sand with silt
10	0.11	0.10	100.00	100.00	99.60	98.9	69.0	3.6	0.0	0.14	1.10	SM Silty Sand
11	0.07	0.07	100.00	100.00	99.70	98.8	95.2	36.8	3.7	0.64	2.80	SM Silty Sand
12	0.09	0.09	100.00	100.00	100.00	99.9	82.5	20.7	2.6	0.18	0.80	SM Silty Sand
13	0.10	0.09	100.00	100.00	99.70	99.4	77.0	8.8	0.0	0.15	1.00	SM Silty Sand
14	0.13	0.12	100.00	100.00	99.60	98.9	55.5	5.5	0.0	0.12	0.50	SM Silty Sand
15	0.14	0.13	100.00	100.00	99.70	98.4	49.9	1.8	0.0	0.10	0.70	SM Silty Sand
16	0.09	0.08	100.00	100.00	100.00	99.9	91.0	23.2	1.7	0.13	1.00	SM Silty Sand
17	0.13	0.12	100.00	99.90	99.50	97.8	52.6	0.4	0.0	0.06	0.70	SM Silty Sand
18	0.12	0.13	100.00	99.90	99.80	98.5	48.6	20.4	5.9	0.64	6.60	SM Silty Sand
19	0.09	0.09	99.70	99.50	99.00	97.6	69.1	36.7	7.7	0.75	3.70	SP-SM Poorly graded Sand with silt
20	0.09	0.08	100.00	100.00	99.90	99.7	89.8	26.4	2.2	0.20	1.40	SP Poorly graded Sand
21	0.09	0.09	100.00	100.00	99.90	99.8	87.5	18.4	2.5	0.27	1.30	SM Silty Sand
22	0.16	0.15	100.00	100.00	99.50	96.6	31.3	0.4	0.0	0.08	0.60	SM Silty Sand
23	0.18	0.17	100.00	99.90	99.50	91.5	16.6	0.3	0.0	0.06	4.30	SM Silty Sand
24	0.11	0.12	99.70	99.60	99.30	97.7	51.3	34.8	8.9	0.67	4.20	SM Silty Sand
25	0.08	0.08	100.00	100.00	100.00	99.8	95.1	20.4	1.7	0.32	1.50	SM Silty Sand
26	0.11	0.10	100.00	100.00	99.50	96.7	67.1	2.6	0.0	0.09	0.80	SM Silty Sand
27	0.16	0.16	100.00	100.00	99.40	95.2	23.2	0.5	0.0	0.06	0.70	SP-SM Poorly graded Sand with silt
28	0.13	0.15	100.00	99.90	99.80	98.6	32.7	19.1	5.0	0.49	1.80	SM Silty Sand
29	0.09	0.09	99.70	99.60	99.30	97.4	80.6	20.3	5.3	0.78	2.10	SM Silty Sand
30	0.07	0.07	99.90	99.80	99.50	91.1	82.3	45.4	7.5	1.40	3.80	ML Sandy Silt
31	0.06	0.06	100.00	100.00	99.90	99.1	98.7	48.6	5.8	1.50	3.70	ML Sandy Silt
32	0.13	0.12	100.00	100.00	99.70	91.9	55.3	9.3	1.8	0.37	1.00	SM Silty Sand
33	0.15	0.15	100.00	100.00	99.20	94.4	34.0	3.4	0.0	0.21	0.80	SP-SM Poorly graded Sand with silt
34	0.11	0.11	99.70	99.60	99.50	97.6	61.6	16.6	4.3	0.40	2.10	SM Silty Sand
35	0.14	0.15	100.00	100.00	99.90	97.7	33.5	17.6	3.5	0.66	2.10	SM Silty Sand
36	0.12	0.12	100.00	100.00	99.90	97.6	53.5	31.2	6.0	0.96	2.70	SM Silty Sand
37	0.19	0.18	100.00	100.00	99.60	83.7	9.9	1.2	0.0	0.09	0.80	SP Poorly graded Sand
38	0.24	0.21	100.00	99.90	98.50	64.1	7.4	1.2	0.0	0.05	0.60	SP Poorly graded Sand
39	0.22	0.21	99.90	99.90	99.50	65.0	16.5	4.5	0.0	0.10	0.60	SP-SM Poorly graded Sand with silt
39A	0.11	0.08	100.00	100.00	99.70	91.1	65.2	37.5	2.9	0.42	2.40	SM Silty Sand
40	0.14	0.15	100.00	100.00	99.90	98.7	30.1	15.6	5.3	0.71	2.20	SM Silty Sand
41	0.15	0.16	100.00	100.00	100.00	98.8	24.6	9.1	3.6	0.64	1.50	SM Silty Sand
42	0.18	0.17	100.00	100.00	99.50	86.9	18.0	0.5	0.0	0.06	0.50	SP Poorly graded Sand
43	0.20	0.18	99.90	99.90	99.00	72.2	23.7	0.4	0.0	<0.05	0.60	SP Poorly graded Sand
44	0.14	0.13	99.9	99.90	99.80	98.6	44.5	7.4	3.3	0.27	1.30	SM Silty Sand
45	0.16	0.16	100.00	100.00	99.70	98.7	24.3	0.5	0.0	0.20	0.70	SP-SM Poorly graded Sand with silt
46	0.14	0.13	100.00	99.90	99.60	98.2	43.5	0.4	0.0	0.09	0.60	SP-SM Poorly graded Sand with silt
47	0.13	0.12	98.70	98.60	98.50	96.0	52.2	0.5	0.0	0.06	0.30	SM Silty Sand
48	0.15	0.14	100.00	100.00	100.00	99.3	36.0	0.8	0.0	0.30	3.00	SP-SM Poorly graded Sand with silt
49	0.13	0.12	100.00	100.00	100.00	99.8	53.7	5.2	2.2	0.13	1.50	SM Silty Sand
50	0.14	0.13	100.00	100.00	99.70	98.4	49.7	0.4	0.0	0.07	0.60	SM Silty Sand
51	0.13	0.12	100.00	100.00	99.60	98.6	54.5	0.3	0.0	0.07	0.70	SM Silty Sand
MAX	0.24	0.21	100.00	100.00	100.00	99.90	98.70	48.60	8.90	1.50	6.60	
MIN	0.06	0.06	98.70	98.60	98.50	64.10	7.40	0.30	0.00	0.05	0.30	

Appendix Table 7.--Detected concentrations of metals (ppm) by station, offshore from the Columbia River, July 1992.

Station no.	TOC %	Arsenic	Cadmium	Copper	Lead	Mercury	Nickel	Silver	Zinc	Chromium
1	0.14	5.0	0.03	6.6	4.9	<0.012	13.00	0.02	48	24
2	0.10	3.7	0.02	5.9	4.3	<0.010	13.00	0.29	51	28
3	0.10	3.9	0.02	5.3	3.5	<0.012	10.00	0.21	41	20
4	0.21	4.1	0.02	3.9	3.7	<0.013	7.60	<0.01	35	14
5	0.11	4.0	0.02	6.2	5.0	<0.012	12.00	<0.01	46	25
6	0.11	2.6	0.03	6.3	4.8	<0.014	13.00	<0.009	49	27
7	0.10	3.7	0.02	6.2	4.4	<0.013	13.00	<0.01	53	29
8	0.10	2.6	0.02	4.8	3.6	<0.013	10.00	<0.01	37	17
9	0.10	4.1	0.02	4.1	4.6	0.014	7.90	<0.01	39	14
9(B)	0.17	3.7	0.02	4.4	4.3	0.014	8.10	<0.01	37	15
10	0.14	3.9	0.02	5.7	3.6	0.018	8.20	<0.01	42	16
11	0.64	8.5	0.12	12.0	6.7	0.029	15.00	<0.01	66	30
12	0.18	3.7	0.02	6.4	5.7	0.020	13.00	<0.01	53	24
13	0.15	3.0	0.03	7.3	2.5	<0.011	11.00	<0.01	48	20
14	0.12	2.3	0.01	5.3	2.8	0.011	12.00	<0.01	48	20
15	0.10	2.6	0.03	5.6	<2.00	0.017	14.00	<0.01	59	31
16	0.13	1.8	0.04	8.4	<2.00	0.019	13.00	<0.01	55	26
17	0.06	2.6	0.05	4.8	2.2	<0.014	12.00	<0.01	50	25
18	0.64	7.8	0.15	7.7	3.9	0.017	14.00	0.10	59	29
19	0.75	6.8	0.19	13.0	7.3	<0.012	15.00	0.16	72	32
20	0.20	3.4	0.08	7.9	4.2	0.019	11.00	<0.01	56	22
21	0.27	2.4	0.08	8.2	2.7	0.028	11.00	<0.01	53	20
22	0.08	1.5	0.01	4.8	<2.00	0.024	12.00	<0.01	45	22
23	0.06	2.2	0.01	3.1	<2.00	<0.014	9.50	<0.01	44	20
24	0.67	4.2	0.08	9.8	5.8	0.019	14.00	0.07	60	30
25	0.32	4.4	0.10	8.7	3.3	0.022	13.00	<0.01	58	26
26	0.09	1.4	0.02	6.6	<2.00	0.014	16.00	<0.01	67	34
27	0.06	1.4	0.01	6.4	<2.00	<0.010	15.00	<0.01	60	31
28	0.49	8.3	0.17	6.7	5.2	<0.014	14.00	0.02	54	29
29	0.78	5.0	0.12	8.4	5.4	<0.014	15.00	<0.01	60	31
30	1.40	7.3	0.19	21.0	7.6	<0.019	16.00	<0.01	86	30
31	1.50	6.4	0.45	20.0	7.1	0.030	14.00	<0.01	84	26
31(C)	1.30	5.0	0.25	21.0	8.1	0.048	15.00	<0.01	91	29
32	0.37	2.4	0.05	8.4	2.5	<0.015	14.00	<0.01	61	30
32(D)	0.35	2.3	0.05	11.0	3.5	<0.014	16.00	<0.01	73	38
33	0.21	2.7	0.05	6.9	2.1	<0.014	13.00	<0.01	51	21
34	0.40	6.6	0.10	5.8	3.7	<0.010	13.00	<0.01	49	28
35	0.66	5.3	0.06	9.9	5.2	<0.016	14.00	<0.01	60	31
36	0.96	5.4	0.12	14.0	5.6	0.021	15.00	<0.01	70	29
36(A)	0.92	3.7	0.14	14.0	8.2	0.023	14.00	<0.01	73	29
37	0.09	1.9	0.02	4.1	2.2	<0.013	8.20	<0.01	33	12
37(E)	0.09	1.6	0.02	4.5	2.0	<0.013	9.30	<0.01	36	16
38	0.05	1.9	0.02	3.5	<2.00	<0.013	9.10	0.11	35	13
39	0.10	2.3	0.03	4.0	3.6	<0.012	12.00	<0.01	47	21
39A	0.42	2.7	0.07	12.0	4.3	<0.014	14.00	<0.01	66	21
40	0.71	3.7	0.06	8.9	4.5	0.020	14.00	<0.01	58	29
41	0.64	2.1	0.04	5.1	4.0	0.015	13.00	<0.01	54	30
42	0.06	1.2	0.01	4.4	<2.00	0.011	15.00	<0.01	62	35
43	<0.05	1.4	0.01	2.5	<2.00	<0.011	11.00	0.15	38	18
44	0.27	2.2	0.02	2.9	4.0	<0.013	15.00	<0.01	47	32
45	0.20	2.3	0.02	2.8	<2.00	<0.013	14.00	<0.01	45	32
46	0.09	1.1	0.01	5.7	<20	<0.009	18.00	<0.01	120	84
47	0.06	1.2	<0.01	18.0	<19	0.012	32.00	<0.01	160	95
48	0.30	3.9	0.02	2.7	4.0	<0.013	20.00	<0.01	45	42
49	0.13	1.6	0.01	1.6	2.1	<0.013	13.00	0.03	45	48
50	0.07	0.7	0.02	9.5	<20	<0.01	<10	<0.01	100	73
51	0.07	4.7	<0.01	2.4	2.2	<0.013	16.00	<0.01	40	30
MAXIMUM	1.50	8.5	0.45	21.0	8.2	0.048	32.00	0.29	160	95
MINIMUM	0.05	0.7	0.01	1.6	2.0	0.011	7.60	0.02	33	12

Note: Values marked less-than (<) indicate method detection limits for an undetected analyte.

Appendix Table 8.--Stations with detected concentrations of pesticides and PCBs (ppb) (in bold), offshore from the Columbia River, July 1992.

Station no.	Aldrin	Chlordane	DDD	DDE	DDT	Dieldrin	Heptachlor	Lindane	PCBs
4	<0.60	<0.60	<0.99	<0.80	**3.4**	<0.80	<0.60	<0.60	<9.9
10	<0.62	<0.62	<1.00	<0.83	<2.1	**3.10**	<0.62	**0.86**	<10
11	<0.68	<0.68	<1.10	**1.20**	<2.3	**6.50**	<0.68	**1.90**	<11
12	<0.62	<0.62	<1.00	<0.83	<2.1	**3.60**	<0.62	**1.50**	<10
13	<0.63	<0.63	<1.00	<0.84	<2.1	<0.84	<0.63	**1.00**	<10
14	<6.20	<0.62	<1.00	<0.82	<2.0	**4.70**	<0.62	**1.60**	<10
15	<0.61	<0.61	<1.00	<0.81	<2.0	**5.00**	<0.61	**1.30**	<10
16	<0.63	<0.63	<1.00	<0.84	<2.1	<0.84	<0.63	**0.78**	<10
17	<0.60	<0.60	<1.00	<0.80	<3.7	**2.70**	<0.60	**1.20**	<10
18	<0.60	<0.60	<1.00	<0.81	**3.0**	**4.30**	<0.60	**1.30**	<10
19	<0.63	<0.63	**1.20**	**2.80**	<2.1	**4.50**	<0.63	**1.20**	<11
20	<0.60	<0.60	<1.00	<0.84	<2.1	**4.10**	<0.63	**2.00**	<10
21	<0.62	<0.62	<1.00	<0.83	<2.1	**1.00**	<0.62	<0.62	<10
23	<0.58	<0.58	<0.97	<0.78	<1.9	<0.78	<0.58	**0.79**	<10
25	<0.62	<0.62	<1.00	<0.83	<2.1	**1.20**	<0.62	<0.62	<10
26	<0.54	<0.54	<0.91	<0.73	<1.8	<0.73	<0.54	**0.71**	<9.0
27	<0.53	<0.53	<0.88	<0.71	<1.8	<0.71	<0.53	**1.40**	<8.8
28	<0.61	<0.61	<1.00	<0.82	**2.8**	<0.82	<0.61	**3.40**	<10
29	<0.60	<0.60	<1.00	<0.80	<2.0	**3.70**	<0.60	**0.95**	<10
30	<0.90	<0.90	<1.50	<1.20	<3.0	**2.20**	<0.90	<0.90	<15
34	<0.58	<0.58	<0.96	<0.77	<1.9	**2.00**	<0.58	**1.30**	<9.6
37	<0.56	<0.56	<0.56	<0.75	<1.9	<0.75	<0.56	<0.56	<9.4
37(E)	<0.54	<0.54	<0.90	<0.72	**2.9**	<0.72	<0.54	<0.54	<9.0
42	<0.53	<0.53	<0.89	<0.71	<1.8	<0.71	<5.30	**0.96**	<8.8
43	<0.53	<0.53	<0.88	<0.71	<1.8	<0.71	<0.53	**0.65**	<8.8
44	<0.60	<0.60	<1.00	<0.80	<2.0	<0.80	<0.60	**0.64**	<10
45	<0.58	<0.58	<0.97	<0.78	<1.9	<0.78	<0.58	**1.40**	<9.7
46	<0.53	<0.53	<0.88	<0.70	<1.8	<0.70	<0.53	**0.89**	<8.8
47	<0.51	<0.51	<0.86	<0.68	<1.7	<0.69	<0.51	**0.80**	<8.6
48	**0.77**	<0.61	<1.00	<0.81	<2.0	<0.81	<0.61	**1.40**	<10
49	<0.54	<0.54	<0.90	<0.72	<1.8	<0.72	<0.54	**1.40**	<9.0
51	<0.53	<0.53	<0.88	<0.70	<1.8	<0.70	<0.53	**1.30**	<8.8
MAX	0.77	ND	1.20	2.80	3.40	6.50	ND	3.40	ND
MIN	0.77	ND	1.20	1.20	2.80	1.00	ND	0.64	ND

Note: Values marked less-than (<) indicate method detection limits for an undetected analyte.

Appendix Table 9.--Stations with detected concentrations of polyaromatic hydrocarbons- LPAH, HPAH (ppb) (in bold), offshore from the Columbia River, July 1992.

Station no.	Ace-naphthene	Ace-napthylene	Anthracene	Fluorene	Napthalene	Phen-anthrene	2-Methl-naphthalene	Total LPAHs	Benzo(a)-anthracene	Benzo(a)-pyrene	Benzo(b,k)-floranthenes	Benzo(a)-perylene	Chrysene	Dibenzo(a,h)-anthracene	Fluor-anthene	Indeno(1,2,3-cd)pyrene	Pyrene	Total HPAHs
11	<22	<22	<22	<22	<22	<22	<22		<22	**22**	<22	**22**	<22	<22	**29**	<22	**37**	**110**
19	<21	<21	<21	<21	<21	**21**	<21	**21**	**24**	**32**	**26**	**24**	**26**	<21	**47**	**23**	**44**	**246**
30	<30	<30	<30	<30	<30	<30	<30		<30	<30	<30	<30	<30	<30	**33**	<30	**35**	**68**
31	<28	<28	<28	<28	<28	<28	<28		<28	**31**	<28	<28	**29**	<28	**38**	<28	**36**	**134**
31(C)	<26	<26	<26	<26	<26	<26	<26		<26	**32**	**38**	<26	**30**	<26	**42**	<26	**45**	**187**
33	<20	<20	<20	<20	<20	<20	<20		<20	<20	<20	<20	<20	<20	**28**	<20	**25**	**53**
36	<22	<22	<22	<22	<22	<22	<22		<22	<22	<22	<22	<22	<22	<22	<22	**22**	**22**
MAX	ND	ND	ND	ND	ND	21	ND	21	24	32	38	24	30	ND	47	23	45	246
MIN	ND	ND	ND	ND	ND	21	ND	21	24	22	26	22	26	ND	28	23	22	22

Note: Values marked less-than (<) indicate method detection limits for an undetected analyte.

Appendix Table 10.--Summary of dioxin analyses at selected stations offshore from the Columbia River, July 1992.

Station no.		2378 TCDF	TOTAL TCDF	2378 TCDD	TOTAL TCDD	12378 PeCDF	23478 PeCDF	TOTAL PeCDF	12378 PeCDD	TOTAL PeCDD	123478 HxCDF	123678 HxCDF	123789 HxCDF	234678 HxCDF	TOTAL HxCDF	123478 HxCDD	123678 HxCDD	123789 HxCDD	TOTAL HxCDD	1234678 HpCDF	1234789 HpCDF	TOTAL HpCDF	1234678 HpCDD	TOTAL HpCDD	OCDF	OCDD
5		-0.35	ND	-0.39	0.76	-0.21	-0.13	ND	-0.09	1.07	-0.17	-0.05	0.46	-0.04	0.72	-0.13	-0.22	-0.26	0.46	0.71	-0.18	0.92	1.30	2.60	-0.37	11.00
6		-0.25	ND	-0.35	0.27	-0.10	-0.15	ND	-0.21	0.47	-0.12	-0.06	-0.27	-0.08	ND	-0.17	-0.36	-0.23	ND	0.40	-0.22	1.40	1.60	3.10	0.60	15.00
7		-0.26	ND	-0.44	0.76	-0.07	-0.09	ND	-0.08	ND	-0.08	-0.75	0.25	-0.09	0.44	-0.13	0.20	-0.23	0.98	0.25	-0.13	1.00	1.00	2.00	-0.46	9.60
8		-0.51	ND	-0.30	0.56	-0.18	-0.13	0.16	-0.09	0.28	-0.14	-0.06	0.31	-0.06	0.71	-0.18	0.10	-0.14	0.26	0.62	-0.06	0.62	0.86	1.80	0.39	8.20
10		-0.66	ND	-0.53	ND	-0.17	-0.09	ND	-0.10	ND	-0.10	-0.10	0.25	-0.10	0.25	-0.20	0.19	-0.19	0.56	0.24	-0.25	1.20	1.20	2.60	0.71	10.00
23		-0.36	1.10	-0.36	1.40	-0.26	-0.17	ND	-0.37	ND	-0.09	-0.21	-0.67	-0.15	ND	-0.37	-0.21	-0.38	0.13	16.00	-0.16	21.00	0.85	1.50	0.65	5.00
26		-0.29	1.50	-0.21	1.90	-0.09	-0.12	0.54	-0.13	ND	-0.06	-0.08	-0.89	-0.14	0.33	-0.08	-0.27	-0.13	0.88	0.30	-0.12	0.30	1.20	1.90	0.50	8.90
28		0.47	0.77	-0.24	0.75	-0.24	0.15	0.50	0.14	0.14	0.17	-0.09	0.47	-0.08	1.50	-0.11	0.73	0.47	6.10	2.00	-0.17	2.00	8.60	18.00	3.30	64.00
37		0.21	0.21	-0.26	ND	-0.22	-0.09	0.47	-0.08	ND	-0.08	-0.08	0.35	-0.08	0.35	-0.09	0.18	-0.13	1.50	0.56	-0.13	0.56	1.70	3.70	0.57	14.00
42		-0.53	ND	-0.60	2.00	-0.21	-0.33	ND	-0.20	ND	-0.14	-0.13	0.74	-0.13	1.10	-0.23	0.20	-0.18	0.20	0.24	0.18	0.42	0.75	0.75	0.60	4.60
45		-0.16	0.07	-0.11	1.40	-0.16	-0.09	ND	-0.11	0.56	-0.11	-0.06	-0.73	-0.22	0.35	-0.11	-0.47	-0.18	1.00	0.39	-0.20	0.85	1.60	3.60	0.79	10.00
MINIMUM		0.21	0.07	0.00	0.27	0.00	0.15	0.16	0.14	0.14	0.17	0.00	0.25	0.00	0.25	0.00	0.10	0.47	0.13	0.24	0.18	0.30	0.75	0.75	0.39	4.60
MAXIMUM		0.47	1.50	0.00	2.00	0.00	0.15	0.54	0.14	1.07	0.17	0.00	0.74	0.00	1.50	0.00	0.73	0.47	6.10	16.00	0.18	21.00	8.60	18.00	3.30	64.00
BLANK-806		0.06	0.06	-0.18	0.45	-0.05	-0.09	0.19	-0.06	0.38	-0.08	-0.06	0.31	-0.11	0.31	-0.09	0.09	-0.11	0.09	0.39	-0.05	0.39	0.79	0.79	0.50	20.00
BLANK-1102		-0.38	ND	-0.33	0.89	-0.40	0.20	0.20	-0.60	0.53	-0.25	-0.17	-0.40	0.37	0.37	-0.62	-0.62	-0.64	ND	-0.68	-0.78	ND	-0.89	ND	1.30	4.30
Broadbalk, G	Soil 1846	0.79	8.50	0.05	0.86	1.10	0.82	10.10	0.13	2.40	1.00	0.63	-0.01	0.66	7.70	0.18	0.31	0.28	5.10	3.30	0.25	4.80	2.80	5.80	2.90	13.00
Broadbalk, G	Soil 1986	1.00	9.00	0.06	1.60	1.00	0.86	10.80	0.27	3.80	1.20	0.81	-0.01	0.53	9.10	0.31	0.57	0.48	8.60	4.20	0.31	6.00	6.30	ND	5.20	25.00
Bothnian Sea	SRE 5 (0-1 cm)	76.00	800.00	9.10	180.00	49.00	70.00	600.00	32.00	470.00	55.00	56.00	38.00	100.00	710.00	34.00	150.00	91.00	#####	NA	NA	720.00	NA	720.00	-9.00	810.00
Bothnian Sea	SRE 5 (30-35 cn	-2.10	64.00	-2.50	100.00	-1.50	-1.00	21.00	-11.80	40.00	-0.70	-1.90	-1.40	-0.07	7.80	-1.70	-1.70	-6.10	42.00	NA	NA	-2.50	NA	32.00	-12.00	-50.00
Baltic Sea **	40 (0-1 cm)	88.00	780.00	8.40	220.00	92.00	91.00	150.00	40.00	620.00	110.00	97.00	29.00	94.00	890.00	34.00	34.00	76.00	#####	NA	NA	#####	NA	#####	23.00	#####
Baltic Sea **	40 (30-35 cm)	-2.10	28.00	-1.50	19.00	-0.70	-0.60	8.20	-1.20	22.00	-1.50	-1.50	-4.00	-2.10	ND	-3.40	-3.40	-5.20	33.00	NA	NA	9.50	NA	39.00	-15.00	-73.00

NOTE 1: Blank-806 was run with Sample Number 5, 6, 7, 8, 10, 28, and 37; Blank-1102 was run with Sample Number 23, 26, 42, and 45.

NOTE 2: (-) indicates none detected, value is the method detection level, (ND) indicates none detected when detection limit is not known, (NA) not applicable.

NOTE 3: (*) Data from Kjeller, Lars-Owe, et al., Environmental Science and Technology. 1991, 25, 1619-1627.

NOTE 4: (**) Data from Rappe, Christoffer, et al., Swedish Environmental Protection Agency, Report March 1987.

Appendix Table 11.--Fishes and large epibenthic invertebrates captured offshore from the Columbia River, July 1992.

Scientific name	Common name	July
Squalidae		
Squalus acanthias	spiny dogfish	x
Rajidae		
Raja binoculata	big skate	x
Clupeidae		
Clupea pallasi	Pacific herring	x
Osmeridae		
Allosmerus elongatus	whitebait smelt	x
Spirinchus thaleichthys	longfin smelt	x
Spirinchus starksi	night smelt	x
Unidentified smelt		x
Gadidae		
Microgadus proximus	Pacific tomcod	x
Cottidae		
Leptocottus armatus	Pacific staghorn sculpin	x
Agonidae		
Occella verrucosa	warty poacher	x
Stellerina xyosterna	pricklebreast poacher	x
Cyclopteridae		
Liparis pulchellus	showy snailfish	x
Bothidae		
Citharichthys sordidus	Pacific sanddab	x
Citharichthys stigmaeus	speckled sanddab	x
Pleuronectidae		
Isopsetta isolepis	butter sole	x
Pleuronectes vetulus	English sole	x
Platichthys stellatus	starry flounder	x
Psettichthys melanostictus	sand sole	x
Microstomus pacificus	Dover sole	x
Invertebrates		
Canceridae		
Cancer magister	Dungeness crab	x
Crangonidae		
Crangon franciscorum	California bay shrimp	x
Lissocrangon stylirostris	smooth bay shrimp	x
Total number of taxa		22

Appendix Table 12.--Summary of 8-m trawling efforts offshore from the Columbia River, July 1992.

Station: 1
Gear: 8-m trawl
Date: 20 Jul 1992
Time: 658
Tide stage: Ebb
Depth: 9.4 m
Distance traveled: 482 m

Species	No. captured	Total wt.(g)	No./ hectare	Wt.(g)/ hectare
Longfin smelt	71	220	295	913
Unidentified juv. smelt	197	123	817	512
Whitebait smelt	345	2,037	1,432	8,452
Pacific tomcod	570	10,712	2,365	44,448
Pacific staghorn sculpin	75	2,693	311	11,174
Pricklebreast poacher	3	16	12	66
Speckled sanddab	17	85	71	353
Butter sole	4	69	17	286
English sole	22	320	91	1,328
Starry flounder	3	231	12	959
Sand sole	13	330	54	1,369
Dungeness crab	11	486	46	2,017
California bay shrimp	7	12	29	51
Smooth crangon	95	27	394	115
TOTALS	1,433	17,362	5,946	72,043

H = 2.50 E = 0.66

Appendix Table 12.--Continued.

Station: 2
Gear: 8-m trawl
Date: 20 Jul 1992
Time: 719
Tide stage: Ebb
Depth: 12.8 m
Distance traveled: 500 m

Species	No. captured	Total wt.(g)	No./ hectare	Wt.(g)/ hectare
Longfin smelt	8	28	32	112
Night smelt	18	71	72	284
Unidentified juv. smelt	12	8	48	34
Whitebait smelt	61	360	244	1,440
Pacific tomcod	1,101	5,048	4,404	20,192
Pacific staghorn sculpin	20	720	80	2,880
Pricklebreast poacher	2	11	8	44
Speckled sanddab	10	49	40	196
Butter sole	6	128	24	512
English sole	4	60	16	240
Starry flounder	8	1105	32	4,420
Sand sole	2	43	8	172
Dungeness crab	2	948	8	3,792
California bay shrimp	10	11	40	48
Smooth crangon	46	8	184	33
TOTALS	1,310	8,599	5,240	34,399

H = 1.13 E = 0.29

Appendix Table 12.--Continued.

Station: 3
Gear: 8-m trawl
Date: 20 Jul 1992
Time: 738
Tide stage: Late ebb
Depth: 15.5 m
Distance traveled: 352 m

Species	No. captured	Total wt. (g)	No./ hectare	Wt. (g)/ hectare
Spiny dogfish	1	1,814	6	10,307
Big skate	2	9,072	11	51,545
Pacific herring	4	136	23	773
Longfin smelt	81	248	460	1,409
Night smelt	27	82	153	466
Unidentified juv. smelt	103	79	585	451
Whitebait smelt	294	1,502	1,670	8,534
Pacific tomcod	978	4,309	5,557	24,483
Pacific staghorn sculpin	65	3,015	369	17,131
Warty poacher	8	21	45	119
Pricklebreast poacher	14	133	80	756
Pacific sanddab	6	373	34	2,119
Speckled sanddab	45	117	256	665
Butter sole	27	2,142	153	12,170
English sole	3	72	17	409
Starry flounder	7	1,628	40	9,250
Sand sole	5	806	28	4,580
Dungeness crab	5	359	28	2,040
California bay shrimp	109	102	619	581
Smooth crangon	294	67	1,670	382
TOTALS	2,078	26,077	11,804	148,170

H = 2.59 J = 0.60

Appendix Table 12.--Continued.

Station: 4
Gear: 8-m trawl
Date: 20 Jul 1992
Time: 758
Tide stage: Late ebb
Depth: 18.6 m
Distance traveled: 556 m

Species	No. captured	Total wt. (g)	No./ hectare	Wt. (g)/ hectare
Spiny dogfish	1	1,253	4	4,507
Big skate	10	6,777	36	24,378
Longfin smelt	141	441	507	1,586
Night smelt	23	96	83	345
Unidentified juv. smelt	178	358	640	1,291
Whitebait smelt	127	580	457	2,086
Pacific tomcod	466	2,462	1,676	8,856
Pacific staghorn sculpin	15	761	54	2,737
Warty poacher	19	19	68	68
Pricklebreast poacher	59	639	212	2,299
Showy snailfish	2	46	7	165
Pacific sanddab	7	1,103	25	3,968
Speckled sanddab	15	26	54	94
Butter sole	54	6,337	194	22,795
English sole	3	245	11	881
Starry flounder	1	102	4	367
Dover sole	1	126	4	453
Dungeness crab	54	5,499	194	19,781
California bay shrimp	408	317	1,468	1,142
Smooth crangon	781	108	2,809	390
TOTALS	2,365	27,296	8,507	98,189

H = 2.87 E = 0.66

Appendix Table 13.--Benthic invertebrate taxa densities (mean number/m^2) found in April, June, and September 1975 and July 1992 at the eight stations used for comparison, offshore from the mouth of the Columbia River.

Taxon	1975			1992
	April	June	September	July
Pleurobrachidae				2.6
Cnidaria				
Anthozoa	0.5	0.5	0.3	
Platyhelminthes				
Turbellaria		0.3		
Nemertinea				
Nemertea	4.0	9.0	20.8	233.1
Nematoda		0.5	0.8	
Annellida				
Polychaeta				
Polynoidae				18.2
Bylgides macrolepida?		1.0		
Harmothoe lunulata		0.5		
Eunoe spp.	0.3			
Tenonia priops		0.5	0.8	13.0
Sigalionidae				3.9
Pholoe minuta	4.3	9.0	7.0	93.8
Sigalion mathildae				7.8
Sthenelais berkeleyi				3.9
Sthenelais tertiaglabra	2.0	3.8	2.0	
Thalenessa spinosa	1.5	5.3	4.8	
Phyllodocidae				5.2
Anaitides spp.		0.3	0.5	
Eteone spp.	0.5	0.5	1.0	
Eteone californica		1.3	4.0	
Eteone longa		0.3	2.3	20.8
Phyllodoce spp.				2.6
Phyllodoce hartmanae				175.8
Phyllodoce mucosa		0.3	0.3	
Phyllodoce groenlandica		1.0	1.0	
Paranaitides polynoides			0.3	1.3
Mysta barbata	0.3			
Eumida sanguinea				35.2
Hesionidae				1.3
Microphthalmus sczelkowii				19.5
Podarkeopsis glabrus				1.3
Sigambra bassi				3.9
Syllidae				16.9
Proceraea cornutus				7.8
Nereidae				7.8
Nereis zonata	0.5		4.0	11.7
Nephtyidae				
Nephtys spp.				250.1
Nephtys caeca	1.5	2.0	1.0	
Nephtys californiensis	2.8	1.8	6.5	2.6
Nephtys caecoides	32.5	36.5	41.0	218.8
Nephtys ferruginea			0.3	19.5
Nephtys glabra		0.3		
Glyceridae				
Glycera capitata	1.8	2.3	2.8	
Glycera nana				2.6

Appendix Table 13.--Continued.

Taxon	1975			1992
	April	June	September	July
Goniadidae				
Glycinde spp.	4.0	17.5	19.8	48.2
Glycinde armigera				214.9
Glycinde picta	3.3	3.3	10.3	28.7
Goniada brunnea				5.2
Goniada maculata	1.8	3.5	2.3	
Onuphidae				44.3
Onuphis iridescens	4.3	9.3	17.0	11.7
Lumbrineridae				3.9
Errano bicirrata	2.0	2.3	3.0	3.9
Lumbrineris latreilli		1.3	0.8	
Scoletoma luti	3.3	4.5	2.8	5.2
Arabellidae				
Notocirrus californiensis	0.3	0.3		
Orbiniidae				310.0
Leitoscoloplos pugettensis	61.5	111.8	108.5	93.8
Scoloplos armiger	7.3	10.5	8.3	2.6
Orbinia (Phylo) *felix*		0.8		5.2
Paraonidae				
Aedicira spp.			0.3	
Aricidea (Acesta) catherinae				10.4
Aricidea (Acesta) pacifica				1.3
Levinsenia gracilis		0.3		
Paraonella platybranchia	0.5	1.0	0.5	3.9
Spionidae				
Laonice cirrata	0.3	1.5	2.5	1.3
Polydora brachycephala				2.6
Polydora caulleryi		10.0	25.5	
Prionospio lighti				74.2
Prionospio steenstrupi	3.8	3.3	1.8	
Spio butleri				1.3
Spio filicornis	3.5	2.8	11.3	11.7
Spio cirrifera	0.5	1.3	2.0	
Boccardia basilaria?		2.0	1.5	
Boccardia pugettensis				1.3
Spiophanes bombyx	21.8	166.8	1,361.3	2,736.6
Spiophanes berkeleyorum	40.8	74.5	209.8	653.9
Paraprionospio pinnata	0.5			2.6
Scolelepis foliosa				15.6
Scolelepis squamata	0.3		0.8	1.3
Magelonidae				
Magelona spp.				104.2
Magelona hobsonae				3.9
Magelona longicornis	1.0	0.8	0.8	11.7
Magelona pitelkai	0.3	1.0		
Magelona sacculata	25.3	31.5	74.8	390.8
Chaetopteridae				19.5
Trochochaeta franciscanum		0.8	2.3	
Spiochaetopterus costarum	0.8	1.5	1.5	5,805.2
Mesochaetopterus taylori				7.8
Cirratulidae				2.6
Aphelochaeta spp.	0.3	1.0	0.5	
Aphelochaeta multifilis	0.5	0.5		1.3
Chaetozone setosa	24.3	41.3	58.8	
Chaetozone spinosa				171.9
Cirratulus cirratus				1.3
Pherusa plumosa			1.5	
Flabelligeridae				1.3

Appendix Table 13.--Continued.

Taxon	1975 April	1975 June	1975 September	1992 July
Opheliidae				
Armandia brevis				19.5
Ophelia spp.	1.3	2.0	2.0	20.8
Ophelina spp.	0.3			
Ophelina acuminata		0.3	0.5	
Travisia japonica		0.8	0.3	1.3
Sternaspida				
Sternaspis scutata			0.3	
Capitellidae		0.3		2.6
Capitella capitata complex			0.5	1.3
Heteromastus filobranchus	0.5	2.5	1.5	
Heteromastus filiformis				2.6
Decamastus gracilis	1.3	6.3	3.8	6.5
Mediomastus spp.				16.9
Mediomastus californiensis		5.5	7.3	5.2
Notomastus lineatus			2.5	3.9
Barantolla americana			0.3	
Arenicolidae				
Arenicola marina				9.1
Abarenicola spp.		0.5		
Maldanidae		1.3		
Asychis disparidentata		0.3		
Euclymene zonalis				22.1
Oweniidae				
Owenia fusiformis	0.5	0.3	2.3	8,123.7
Galathowenia oculata	6.0	8.8	37.3	44.3
Myriochele heeri		0.3		
Pectinariidae				
Pectinaria spp.			0.5	16.9
Pectinaria californiensis	0.3			10.4
Pectinaria granulata		0.5		
Ampharetidae				1.3
Ampharete acutifrons	5.8	8.0	12.5	5.2
Terebellidae				6.5
Pista cristata	0.5		0.3	
Polycirrus spp. complex	0.5	0.8	4.3	3.9
Lanassa spp.			18.3	
Sabellidae				
Chone albocincta			0.3	
Hirudinea			0.3	
Gastropoda				1.3
Naticidae				
Nitidella gouldi	7.8	2.3	5.0	19.5
Nassariidae				
Nassarius spp.				14.3
Nassarius mendicus	2.3	1.8	1.5	1.3
Nassarius fossatus	0.5	0.8	3.5	36.5
Olividae				
Olivella spp.				76.8
Olivella biplicata	3.3	1.8	2.5	
Olivella baetica	8.8	8.5	7.5	9.1
Olivella pycna	30.8	19.5	15.3	26.1

Appendix Table 13.--Continued.

Taxon	1975 April	1975 June	1975 September	1992 July
Turridae				
Kurtziella plumbea				5.2
Oenopota spp.				1.3
Oenopota turriculata			0.3	
Pyramidellidae				
Odostomia spp.	6.8	4.3	6.8	11.7
Turbonilla spp.		0.3		
Turbonilla aurantia	2.0	0.8	1.0	
Cylichnidae				
Acteocina spp.	0.3			
Cylichna attonsa	1.8	6.3	4.5	10.4
Scaphandridae				
Scaphander willetti				27.4
Aglajidae				
Melanochylamys diomedea		5.5	4.8	
Gastropteridae				
Gastropteron pacificum			1.3	13.0
Pelecypoda		0.3		2.6
Nuculidae				
Acilla castrensis	187.0	174.5	169.3	58.6
Nucula tenuis	13.5	18.0	16.0	5.2
Yoldia seminuda	1.5	3.0	3.5	
Mytilidae				297.0
Musculus spp.	0.3	0.5	4.0	
Thyasiridae				
Axinopsida serricata	41.0	48.0	46.3	62.5
Thyasira flexousa		0.5		
Cardiidae				
Clinocardium spp.				2.6
Cutellidae				
Siliqua spp.				39,640.3
Siliqua patula	3.8	145.8	168.5	
Siliqua sloati				1.3
Solen sicarius				7.8
Tellinidae				
Macoma spp.				596.5
Macoma moesta alaskana	4.5	16.5	11.3	
Macoma elimata ?	0.5	0.5		
Macoma calcarea		0.5		
Tellina spp.		0.3		62.5
Tellina modesta	16.8	22.0	17.5	9.1
Tellina bodegensis				1.3
Pandoridae				
Pandora punctata		0.3		
Lysoniidae				
Lyonsia californica			0.5	
Dentaliidae	3.0	4.5	3.3	
Gadilidae				2.6

Appendix Table 13.--Continued.

Taxon	1975 April	1975 June	1975 September	1992 July
Crustacea				
Cylindroleberididae				15.6
Bathyleberis spp.	1.5	1.8	1.0	
Cypridinidae				
Euphilomedes spp.				35.2
Euphilomedes carcharodonta	8.8	7.0	18.8	182.4
Euphilomedes productus		0.3		
Cirripedia				2.6
Nebaliidae				
Nebalia bipes			0.5	
Nebalia pugettensis				16.9
Mysidacea				
Mysidae				
Acanthomysis spp.				1.3
Alienacanthomysis macropsis	0.3			
Exacanthomysis davisi		0.5		
Exacanthomysis alaskensis		0.3		
Pacificanthomysis nephrophthalma	0.5	1.8	0.8	
Archaeomysis grebnitzkii	3.0	0.5	0.5	2.6
Neomysis kadiakensis	0.5			
Cumacea				
Lampropidae				
Mesolamprops spp.	4.8	11.5	2.0	
Lamprops spp.	0.3	0.5	0.3	
Hemilamprops californica	17.3	7.5	7.5	22.1
Leuconidae				
Eudorellopsis longirostris			0.3	
Leucon spp.		0.3		39.1
Diastylidae				
Diastylis spp.		0.3		
Diastylis alaskensis	4.8	0.8	3.8	
Diastylis bidentata	1.8	5.0	1.0	
Diastylopsis spp.				148.5
Diastylopsis dawsoni	280.8	1,310.3	2,307.5	11.7
Diastylopsis tenuis	7.0	4.5	1.8	20.8
Colurostylidae				
Colurostylis occidentalis	14.0	3.3	0.8	7.8
Campylaspis rubromaculata		0.3		
Isopoda				
Sphaeromatidae				
Tecticeps convexus	37.3	10.5	2.0	11.7
Bathycopea daltonae	5.3	3.3	2.3	
Idoteidae				
Synidotea bicuspida	4.8	4.8	1.3	
Synidotea angulata			0.3	3.9
Edotea sublittoralis			0.3	
Munnidae				
Munna spp.				2.6
Pleurogonium rubicundum	0.3		1.3	

Appendix Table 13.--Continued.

Taxon	1975			1992
	April	June	September	July
Amphipoda				22.1
Ampeliscidae				
Ampelisca spp.				11.7
Ampelisca hancocki			0.3	
Ampelisca macrocephala	59.0	97.8	35.5	95.1
Argissidae				
Argissa hamatipes	0.8	1.8	2.0	
Atylidae				
Atylus tridens	7.3	12.0	0.5	
Corophidae				
Corophium spp.			0.3	
Podoceridae				
Dulichia spp.	0.5	1.5	0.3	
Eusiridae				
Rhachotropis oculata			0.8	
Haustoridae				
Eohaustorius spp.				33.9
Eohaustorius sencillus	35.8	31.0	20.0	19.5
Hyalidae				
Allorchestes spp.		1.5		
Parallorchestes spp.				7.8
Anisogammaridae				
Anisogammarus pugettensis		0.3	0.3	
Isaeidae				
Photis brevipes	7.0	14.3	4.5	
Photis lacia	4.0	10.8	3.0	
Photis macinerneyi				113.3
Photis parvidons				13.0
Protomedeia spp.	2.5	27.3	11.3	23.4
Cheirimedia zotea	0.3	1.0	1.0	
Ischyroceridae				
Ischyrocerus megalops	0.3	13.0	0.5	
Lysianassidae				
Anonyx adoxus	0.3	3.0		
Hippomedon spp.	1.3	1.3	2.3	
Opisa tridentata		0.3		
Orchomene spp.	0.5	0.5	0.5	5.2
Orchomene pacifica		1.3	3.3	
Orchomene pinquis				26.1
Pachynus c.f. barnardi		0.3		1.3
Wecomedon wecomus		0.3		
Oedicerotidae				
Monoculodes spp.	2.0	3.5	6.0	6.5
Monoculodes spinipes	15.3	8.5	5.5	
Synchelidium shoemakeri	5.0	5.5	8.0	13.0
Synchelidium rectipalmun	0.3	0.8	1.0	
Westwoodilla caecula	0.5	1.0	0.8	
Phoxocephalidae				
Paraphoxus spp.		0.8		
Foxiphalus major	13.8	10.8	4.8	23.4
Rhepoxynius fatigans	23.3	42.5	31.3	
Mandibulophoxus gilesi				7.8
Mandibulophoxus uncirostratus	3.3	4.8	6.3	

Appendix Table 13.--Continued.

Taxon	1975 April	1975 June	1975 September	1992 July
Rhepoxynius spp.				125.0
Rhepoxynius abronius				15.6
Rhepoxynius daboius				142.0
Rhepoxynius epistomus?	11.0	11.0	6.0	
Rhepoxynius variatus	1.3	2.5	1.5	
Rhepoxynius vigitegus	7.8	9.5	6.8	44.3
Pleustidae				
Parapleustes spp.				10.4
Pleusymtes coquilla	1.8	2.5	3.8	
Stenothoidae				5.2
Aeginellidae				
Mayerella banskia		0.3	0.5	
Tritella pilimana			0.5	
Decapoda				
Callianassidae				
Callianassa californiensis				11.7
Paguridae				
Pagurus spp.				2.6
Pagurus armatus	0.3			
Pagurus ochotensis	0.5			
Pagurus caurinus	0.8			
Pagurus quaylei			0.5	
Canridae				
Cancer magister		2.3	1.3	
Onychophora				
Pinnotheridae				
Pinnixa spp.	1.3	0.3	2.5	5.2
Sipunculidae				1.3
Echuirida		0.5		37.8
Phoronida				18.2
Phoronidae				
Phoronis psammophila?	1.3	2.5	1.5	
Ophiuroidea				1.3
Amphiuridae				1.3
Amphiodia spp.				110.7
Amphiodia periercta-urtica	54.5	45.0	34.5	
Echinoidea				353.0
Dendrasteridae				
Dendraster excenticus	0.8		0.8	10.4
Holothuroidea				
Paracaudina chilensis	7.3	9.0	8.3	
Mean total	1,277	2,864	5,190	63,171
Number of taxa	119	152	146	163

Appendix Table 14.--Summaries of benthic invertebrate collections by station, for eight stations selected for comparison offshore from the Columbia River, April, June, and September 1975 (available upon request from National Marine Fisheries Service, Point Adams Biological Field Station, P.O. Box 155, Hammond, OR 97121).